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AN EARLIER AMERICAN MAMMAL SOCIETY

BY HARTLEY H. T. JACKSON

We of the American Society of Mammalogists usually take pride in the belief that we were the first mammal society. This Society was the first to continue as a successful mammal organization in this or any other country. It served as an inspiration and somewhat as a model for the Deutsche Gesellschaft für Säugetierkunde, organized in Berlin, January 18, 1926. At the time of the organization meeting of our Society, April 3, 1919, it was the general opinion that this was the first attempt to organize a mammal society. I was one who held this opinion until several years later when, from a batch of old reports and papers given to me by a friend, I dug a little eight-page pamphlet, $5\frac{3}{8}$ x $3\frac{1}{2}$ inches in size, no covers, entitled "Constitution of the Pacific Coast Mammological Club." No date of publication appears, but it was undoubtedly during 1904. The misspelled "mammological" was not continued in the text.

On July 22, 1947, I wrote to Dr. Walter K. Fisher, one of the two living members of the Club, the other being R. B. Herron, telling him of my possession of the pamphlet and asking him if he could supply any pertinent information not contained in the booklet. Although the Club "died young," nevertheless so far as is known it should be given credit as the first mammal society, particularly inasmuch as it issued at least the one publication. Doctor Fisher's interesting reply to my letter follows:

HOPKINS MARINE STATION

PACIFIC GROVE, CALIFORNIA
July 30, 1947

DEAR DR. JACKSON:

The Pacific Coast Mammalogical Club was the child of Frank Stephens. It died young for the want of nourishment in the form of members and real interest in the subject. I can't even recall the names of the few members except Grinnell and, of course, its "Father." I dimly remember that we had a meeting at Berkeley and tried to get W. E. Ritter to join as he always had something good to contribute if it were only advice; but he had already too many irons in the fire, and declined. I was never elected president. Stephens asked me to serve, through his friendship with "A. K." [Walter Fisher's father, Dr. A. K. Fisher] to get the thing started. But I was a poor choice I think as at that time I was engrossed in the Cooper Club. After writing to everybody who might be interested I finally gave it up as a premature venture.

As a matter of fact the whole thing had completely slipped out of mind until the receipt

of your letter. When I moved to Pacific Grove in 1918 I must have chucked all the correspondence along with that pertaining to the old Cooper Club days, for I can not find Stephens name in my files. *Sic transit gloria juventulis!*

With best regards,

Sincerely,

W. K. Fisher

This little document has such interest and importance in the history of mammalogy that it is here placed on permanent record in its entirety.

CONSTITUTION

—of the—

PACIFIC COAST MAMMOLOGICAL CLUB

ARTICLE I.

Section 1. This society shall be known as the Pacific Coast Mammalogical Club.

Sec. 2. The objects of this Club shall be the study and advancement of the mammalogy of the Pacific slope of North America.

ARTICLE II.

Section 1. Any person actively interested in the study of the natural history of mammals, a resident of the Pacific slope of North America, and acceptable to a majority of the members, is eligible to active membership in the Club.

Sec. 2. Honorary and corresponding memberships may be provided for in the by-laws.

ARTICLE III.

Section 1. The officers of the Club shall be a President, Secretary, and Treasurer. These three officers, with two other members appointed annually by the President, shall constitute the Executive Committee.

Sec. 2. The duties of the officers shall be those usually performed by such officers. The Executive Committee shall have charge of all business not directly provided for by the Club itself.

Sec. 3. The officers shall be elected annually in December, and shall take office the first of January. Election shall be by a plurality vote of the members voting.

Sec. 4. The by-laws may provide for the formation of Divisions for the more effectual execution of the objects of this Club.

Sec. 5. Meetings may be provided for by the by-laws, it being understood that owing to the scattered membership the principal work of the Club must be performed by correspondence.

ARTICLE IV.

Section 1. Election of members shall be by a two-thirds vote, in writing, after proposal through a member of the Club. Any member proposing an unworthy candidate shall be liable to suspension.

Sec. 2. Resignations shall be made in writing to the Secretary.

Sec. 3. Suspensions of membership for delinquency of dues or assessments shall be final in one year from notification of delinquency by the Secretary, if not paid up within that time. For other causes suspension shall be for the term voted by the Club. Members suspended are not entitled to any privileges of the Club within the term of suspension.

Sec. 4. A member may be expelled from the Club by a two-thirds vote of the members, after fair notice, for improper use of his membership, or such other reasons as may be defined in the by-laws.

ARTICLE V.

Section 1. Funds receivable are to be paid to the Treasurer, who shall receipt for them. Bills payable shall be presented to the Secretary and paid by an order on the Treasurer signed by the Secretary and President.

Sec. 2. Dues and assessments may be provided for in the by-laws.

ARTICLE VI.

Section 1. Amendments to the Constitution may be proposed by the Executive Committee and must have three-fourths of the votes received to carry.

Sec. 2. Amendments to the By-laws may be proposed by two or more members, and must receive a two-thirds vote to carry.

SOME PROPOSITIONS

The Pacific Coast Mammalogical Club starts with a small and widely scattered membership. As regular club meetings are not practicable, other methods of work capable of being carried on by correspondnece must be adopted. Among those proposed are some that are likely to prove useful.

One is to form a club reference library which can be utilized by members. If members or friends of the club, who have duplicate papers bearing on mammalogy to spare, will send them to the secretary they will be cared for and held subject to the orders of the club. The secretary will look up items desired in the library and make a reasonable amount of abstracts for members at any time.

Another suggestion is to gather descriptions of new forms of Pacific Coast mammals, changes of nomenclature, etc., as they come out, and at intervals send abstracts to all members. Probably none of us get all these, but if each member will send the secretary a brief note on those he gets, we can combine them so as to include nearly all. The majority of our members get very few such papers. It would be a great help to the club if authors having duplicates to spare would donate copies to the club library. The club is not at present able to do much to return such favors.

It has also been suggested that the club get out a check list of Pacific Coast mammals. Funds are lacking for such in this line now, but it might be possible to make a beginning in installments. It should be borne in mind that such a list is but a tool for use in doing higher work.

So little is so really known of the life histories of our mammals that we hope all members will make all notes possible and preserve them. Possibly a way may be found in the future to utilize them.

Suggestions for work within our limited means will be very welcome. We are all more or less isolated from other workers in this field and one member's need is similar to that of others.

OFFICERS, 1904.

President, Walter K. Fisher, Palo Alto, Cal.
Secretary, Frank Stephens, University and Fillmore Aves., San Diego, Cal.
Treasurer, Harry S. Swarth, 612 Coronado St., Los Angeles, Cal.

FOUNDERS, 1903.

Anderson, Malcolm P., Menlo Park, Cal.
Anthony, A. W., 900 Thurman St., Portland, Oregon.
Brown, Herbert, Yuma, Arizona.
Fisher, Walter K., Palo Alto, Cal.
Grinnell, Joseph, Pasadena, Cal.

Heller, Edmund, Riverside, Cal.
Herron, R. B., San Bernardino, Cal.
Holzner, Frank X., 1431 F St., San Diego, Cal.
Jenkins, H. O., Stanford University, Cal.
Koch, Fred W., 2043 Berryman St., Berkeley, Cal.
Price, W. W., Alta, Placer Co., Cal.
Ritter, Wm. E., University of California, Berkeley, Cal.
Stephens, Frank, University and Fillmore Aves., San Diego, Cal.
Swarth, Harry S., 612 Coronado St., Los Angeles, Cal.
Wilder, H. E., R. F. D. No. 1, Riverside, Cal.
Wright, W. G., 445 F St., San Bernardino, Cal.

BY-LAWS

I.

Proposals for membership received by the Secretary shall be mailed to all members, who are expected to return their votes immediately to the Secretary. One month after sending out proposals for membership the Secretary shall notify the President of the number of votes received for and against a candidate. The President shall declare accordingly. The individual votes must be kept secret from all but the Executive Committee.

II.

Upon notification of election by the Secretary, members-elect must forward the dues for the current year.

III.

Annual dues shall be one dollar, payable at the beginning of each year. Assessments may be levied by the Executive Committee only for urgent needs. The Executive Committee may request the Secretary to submit a proposition for assessment to the members for any purpose they may deem advisable. Such proposition must have two-thirds of the votes received to carry, one month being given for notification and reply. Dues and assessments shall be delinquent in six months, when notifications shall be mailed to delinquents by the Secretary.

IV.

Meetings may be called by the President at any time and place, when he is satisfied that five or more members can be got together.

Biological Surveys, U. S. Fish and Wildlife Service, Washington, D. C. Received Sept. 15, 1947.

HABITS AND ECONOMIC RELATIONSHIPS OF THE TULARE KANGAROO RAT

By Henry S. Fitch

On grazing lands throughout the western United States, native rodents compete with livestock for the forage crop. A species characteristic of the lowland range areas in California is the kangaroo rat (*Dipodomys heermanni*). It occurs mainly in the Sacramento—San Joaquin Valley plains and in the foothills of the Sierra Nevada and inner Coast Ranges. Its habitat is in an annual type vegetation and an arid climate, where grazing is the principal land use. In parts of this area it is one of the more important wildlife species competing with grazing livestock.

The present study was undertaken in collaboration with the California Forest and Range Experiment Station of the U. S. Forest Service at the San Joaquin Experimental Range. The aim was to investigate the populations and feeding habits of this rodent to determine the extent of its competition with livestock. This was one phase of a program to investigate the ecology of range rodents, originally planned and undertaken by Mr. Everett E. Horn of the U. S. Fish and Wildlife Service. Assistance was received from many persons during the course of the study. Participants in the extensive live-trapping operations were Lowell Adams, Henry Hjersman, Freeman Swenson, Frank Hagarty, and Jack Ramley. The latter also made road counts and, with Richard Taber, sorted and identified seed hulls from burrow mounds. Oscar Hornback made observations on bait preferences and hours of activity. Howard Twining, Daniel F. Tillotson, and John E. Chattin analyzed scat and pellet material which served as a basis for predation studies. Harold H. Biswell and Jay Bentley identified plant materials.

Field work included several independent lines of investigation, but most time and effort was expended in live-trapping on an eighty-acre area in an attempt to determine population density, and annual and longtime cycles, from the careers of individual rats which were marked and recaptured. This work, begun in 1938 and continued until May, 1942, was resumed for a period of weeks in the early spring of 1946. Altogether, 2106 kangaroo rats were live-trapped and marked on this area; 386 in 1938, 633 in 1939, 525 in 1940, 450 in 1941, 26 in 1942, and 86 in 1946. A total of 10,647 captures were recorded; 868 in 1938, 2608 in 1939, 3512 in 1940, 2977 in 1941, 421 in 1942, and 261 in 1946. Trapping was begun on a small scale in May, 1938, and was gradually intensified as more traps became available. This trapping was carried on almost the year round, but was partly suspended during cold wet weather in December and January when trap mortality was apt to be high. Few were caught in April because of poor bait acceptance. For a period of months in 1940, traps were placed in a grid arrangement spaced at 40-foot intervals. This system was abandoned as too time consuming with the large number of traps to be tended and moved. By careful distribution of traps with reference to kangaroo rat sign, the area could be trapped just as thoroughly with much less time and effort.

The whole eighty acres was usually trapped twice each month. Each time,

traps were kept set for from three to six nights, which were not consecutive. A one-fourth acre kangaroo rat enclosure was installed, in 1935, with an adjacent enclosure used as a control; in these, measurement of the vegetation was made in 1936–43, and in 1946. In 1939 and 1940, night counts were made by driving an automobile over several miles of roads in different pastures of the Range. Feeding habits were further studied by analysis of discarded seed hulls in the soil of the burrow mounds, by excavation of the burrows, and by cheek pouch contents of rats trapped or found dead.

HABITAT

Open, well-drained situations are preferred. Grinnell (1933: 157) defines the habitat of this subspecies as: "ordinarily dry, grassy plains and partly open, gravelly ground on hillsides clothed sparsely with chaparral." The latter half of this statement applies best to the population studied, near the species' upper altitudinal limit in the foothills, in an area of poor shallow soil, with extensive outcrops of granitic rocks in the blue oak—digger pine—live oak association. The woods of these three tree species is open and orchard like, or sometimes fairly thick, alternating with open grassland many acres in extent. There are occasional patches of chaparral, consisting of ceanothus, manzanita, and coffeeberry. In some more hilly locations, steep slopes are cut by narrow ravines, but mostly the topography is of gentle slopes and knolls alternating with swales. The vegetation is of an annual type, a mixture of many forbs and grass species, which grows during the cool rainy months of late fall, winter, and early spring, and is dry throughout the summer.

Within this general habitat, the kangaroo rat is localized. It avoids well wooded situations, thick chaparral, steep rocky slopes, and open swale land. Its numbers are concentrated on knolls and ridges, where the soil is shallow and well drained and the vegetation is scanty. In winter months, the swales are often saturated with water, which would preclude burrowing there by the rats, but even in summer they are not invaded to any great extent. The rank growth of vegetation there evidently is unfavorable. Open ground, permitting an unobstructed view and rapid running, appears to be an ecologic necessity.

At times, when moderate or high population densities are attained, signs of activities are conspicuous on relatively barren knolls and ridges, which are then criss-crossed by a maze of beaten pathways. Some of these trails end blindly at foraging places in vegetation; others lead to open spots used for dusting and playing or to the shelter of burrows, rocks, or brush. Dead and prostrate shrubs of wedge-leaf ceanothus (*Ceanothus cuneatus*), with their dense interlacing twigs and with protected annual vegetation growing through them, provided favorite coverts for many kinds of wildlife. Kangaroo rat burrows are often situated beneath the edges of such dead brush or beneath the live shrubs. Centers of surface activity were often in places where flattened protrusions of the granite substrate through the thin soil layer provided level rocky surfaces and barren marginal areas of coarse thin soil. Abundantly strewn feces evidenced that much time was spent in such open spots.

In the more brushy situations frequented by kangaroo rats, where brush patches

alternated with open spaces, cottontails, also common, had beaten runways between clumps of chaparral. Such trails as well as those of ground squirrels and other mammals which happened to share their habitat were regularly used by kangaroo rats. The kangaroo rats' awkwardness in thick vegetation, and their preference for open situations, leads to their use of such trails as well as of roads, fire-breaks, and the dusty trampled ground around salt-licks.

BURROWS

Burrows in current use usually are readily identified by several features as belonging to this species. The burrow mounds are characteristically long and narrow as if thrown out from inside the entrance by powerful strokes of the hind feet. The soil composing them is finely pulverized, often with seed hulls mixed in. One or more well worn trails usually lead from the entrance to other holes or foraging places. The most used holes, those from which soil is thrown out, usually descend into the ground at a gentle gradient and are of considerably greater diameter than the animal itself, facilitating rapid entry. Other small holes, perhaps used only as exits or in emergencies, come to the surface almost vertically, with little or no evidence of activity around them.

In January, 1940, in an area where kangaroo rats were abundant and had left much evidence of their activity, 118 apparently active burrows were dug out. The burrows selected had either well worn runways leading to them, conspicuous fresh sign, diggings or scratchings about the entrances, or plant cuttings. Most of the burrows were gassed with exhaust from an automobile before excavation was begun. Contrary to expectations, only five of the 118 contained kangaroo rats, one in each. An additional thirty-two burrows were dug out in October, 1939, and March, 1940. For the entire lot of 150 burrows the following averages were obtained: Number of open holes per system, 1.4; maximum depth, 7.64 inches; length of tunnel per system, 10.7 feet.

Most of the burrow systems, 88 per cent, had blind ends: in 62 per cent there was one, in 21 per cent there were two, in 4 per cent there were three, and in one per cent there were four. Some of the blind ends came almost to the surface and were partitioned off by thin crusts of earth an inch or less in thickness. They could be easily broken through as an exit—an obvious escape device against snakes and digging predators. Twenty-one of the burrows, less than one-seventh of the total, had this construction; three of the twenty-one had two such surface ends. The most notable characteristics of the burrows were simplicity and lack of any definite pattern. Of the total number, sixty-eight were of the simplest possible construction, consisting of only one hole and an unbranched tubular burrow with a blind end. Nine others each consisted of a simple, tubular burrow with a surface entrance at each end. The remaining seventy-three had various additional features of one or more side passages, either ending blindly or leading to the surface. Lateral blind pockets, of 3 to 6 inches in length, were frequent, and sometimes contained remains of food stores. Blind ends were sometimes enlarged as nest cavities. Old nests were found in eleven, and old food caches in seven, of the unoccupied burrows.

The findings with regard to burrow systems are in sharp contrast with those of

Tappe (1941) at Panoche and Corral Hollow on the west side of the San Joaquin Valley. He stated that burrows excavated by him averaged about 35 feet of open tunnel—more than three times the average tunnel length on the Experimental Range where only one of the 150 burrows excavated exceeded that average, with a length of 42 feet. No others exceeded 30 feet, and only ten exceeded 20 feet. Tappe differentiated between "main" and "subsidiary" burrows; the former are those occupied by rats as their usual daytime retreats. He described the main burrows as having a two-story or three-story arrangement of tunnels, which was not found in the present investigation. "The main burrow is of simple construction, from six to 20 inches under the surface, and consisting usually of one main tunnel extending the entire length of the system with numerous loops and side branches, some of which end blindly with enlarged ends. . . . Usually there are several tunnels dug from below to within one-half inch of the surface through which the animal can quickly dig or break to the surface. . . . Subsidiary burrows have a less extensive tunnel system, and are simpler in construction than main burrows. They usually have one, two, or three entrances opening into a single, relatively straight tunnel that may have one or more side branches. These side branches, as in the main burrows, sometimes loop back to rejoin the main tunnel, or may lead to an opening, or, as is usually the case, to a chamber just below the surface. . . . Apparently subsidiary burrows serve only for temporary refuges or as 'duck-ins' . . . even what on the surface appear to be subsidiary escape burrows, may, in fact, be occupied." (Tappe, 1941: 120, 122).

Tappe's whole account of the burrows of *D. h. tularensis*, while describing many details which were likewise noted at the Experimental Range, seems to indicate more extensive burrowing and more complex burrow systems in the localities where he worked. This difference may be attributed to the fact that Tappe's observations were made in areas of fine deep soil, whereas in the locality of this study the soil is shallow, coarse, and rocky and consists mainly of decomposing granite. Even the occupied burrows of this investigation, while averaging somewhat better in construction than the others, were simpler than the "subsidiary" burrows of Tappe's study. Dimensions and construction of the six burrows from which kangaroo rats were secured or escaped are given in Table 1.

While these occupied burrows averaged nearly twice as deep and half again as long as the others, they were not noticeably different in construction. Perhaps the use of straw nests occurs mainly during cold and damp weather. The five rats dug out in January all had such nests, but the one taken in March was in a simple burrow containing no nest or nest cavity. Tappe found nine nests in seventeen main burrows. He suggested that the nest is used only for rearing young and that the animal at other times used the loose earth of the burrow floor for resting.

Dale's (1939: 708) description of the habitat of *Dipodomys heermanni saxatilis*, at a locality 260 miles NNW of the Experimental Range in a continuation of the same foothill belt, is significant in revealing environmentally imposed variation in habits. In that region, characterized by hard packed soil less than six inches deep over extensive areas, with the underlying rock projecting through it fre-

quently, the kangaroo rats are abundant and find shelter almost entirely beneath residual boulders. In places where boulders are scarce, as at the type locality, Paines Creek, the kangaroo rats are correspondingly scarce. Though no actual excavations are described by Dale, it is evident that in that rocky habitat burrows are much shorter and shallower than those of the Experimental Range. He wrote (*op. cit.:* 714) "One noteworthy fact about all the burrows investigated was their shallowness. This is, of course, necessary in many places because the soil is shallow but appears to be a characteristic of the animal even in places where the soil is deep enough to permit digging at greater depths."

TABLE 1.—*Construction and dimensions of several occupied kangaroo rat burrows*

NUMBER OF OPEN HOLES	NUMBER OF DEAD ENDS	LENGTH OF TUNNEL IN FEET	GREATEST DEPTH IN INCHES	NEST SIZE IN INCHES	DATE
2	nest	8	12	6 x 3	Jan. 15
2	one and nest	11	24	?	Jan. 15
2	one and nest	7	7	6 x 5	Jan. 19
2	none	29	18	9 x 4	Jan. 23
2	none	14	18	?	Jan. 23
2	2	18	5	(none present)	Mar. 11

Number of open holes appears to be a poor criterion of the kangaroo rat population present since it is much altered by type of soil and by the population levels during preceding years. For the 150 burrow systems excavated in the winter of 1939–40, there were thirty-five open holes for each kangaroo rat found. However, there is a possibility that some escaped unseen. In December, 1939, on the eighty acres where live-trapping was done, 2225 open holes that showed evidence of use were identified as those of kangaroo rats. The area was heavily populated with ground squirrels; 3485 of their burrows were counted. Many of these squirrel holes were used by kangaroo rats. Their surface runways often led to the entrances, where, on various occasions, they were caught in traps. Since the kangaroo rats themselves are not strong diggers, the deep and spacious burrows of the squirrels provide shelter from within which the rats are able to dig their own tunnels more easily. Many of the burrows were either deserted entirely by the squirrels, or were used merely as emergency escapes. On the Experimental Range it seemed probable that kangaroo rat burrow systems were often parts of old gopher diggings, at least they were of the same depth and general conformation. On the ridges and knolls inhabited by the kangaroo rats, gophers were numerous during the rainy season.

In turn, the kangaroo rats, through their burrowing, provide places of shelter for many other kinds of small animals. Various invertebrates such as camel crickets (*Ceuthophilus*), sow bugs, and "tarantulas" (*Eurypelma*) frequent their burrows regularly. Also, reptiles and amphibians often use them. In the 125 winter burrows excavated, two spadefoot toads were found on January 23 and 24 at depths of 5 and 18 inches; a fence lizard was found on January 22 at a depth of 3 inches; and a gopher snake, on the same date, at a depth of 4 inches. All were

in blind pockets. In summer, the burrows are favorite retreats for whiptails (*Cnemidophorus tessellatus*) and brown-shouldered lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) and several other kinds of snakes have often been seen emerging from the burrows or escaping into them.

FEEDING

The storing habits of this rodent further complicate the difficulty of making an appraisal of its effect on the forage crop; quantities eaten may be subject to only slight variation, but the quantities transported and stored may be much greater and would vary according to the amount and composition of the forage crop.

As compared with some other species of the same genus, notably the bannertail (*Dipodomys spectabilis*) and the giant kangaroo rat (*Dipodomys ingens*), the present form has the storage habit but little developed This fact was noted by Tappe (1941: 124) who offered the explanation that within its range weather conditions and food supply are so generally favorable as to render the accumulation of extensive food stores unnecessary. The same author (*op. cit.*: 125) lists various kinds of seeds comprising the burrow caches in the following order of importance, according to weight and frequency of occurrence: red brome, redstem filaree, soft chess, oat, lupine, lotus, clover, and red maids. Season is not indicated.

In the present study, feeding data were gathered from three sources: cheek pouch contents of animals trapped or otherwise secured, burrow caches, and siftings of discarded seed hulls from burrow mounds. In all, 163 kangaroo rats were recorded as having natural foods in their cheek pouches, and these were distributed seasonally as follows: two in January, one in February, one in March, three in April, eleven in May, fourteen in June, twenty-nine in July, forty-one in August, thirty-three in September, sixteen in October, eight in November, and four in December. Many of these records were obtained from the rats live-trapped and released on the study area, but the thousands of captures there provided relatively few feeding records because most had their pouches crammed with the grain bait, and apparently had discarded any natural food which they might have been carrying. In contrast, those that had met accidental death, by being run over by automobiles or by rattlesnake bites, often had their pouches filled with seeds. These records nearly all represent the dry season—May to November. The few December to April items are different in trend and are omitted for the present. The dry season samples consisted mostly of seeds (5371 items) as follows: soft chess (*Bromus mollis*), 2377 seeds; foxtail fescue (*Festuca megalura*), 1716 seeds; filaree (*Erodium botrys* and *cicutarium*), 588 seeds, 6 stem sections, and 2 stem joints; red brome (*Bromus rubens*), 385 seeds; turkey mullein (*Eremocarpus setigerus*), 166 seeds; ripgut brome (*Bromus rigidus*), 57 seeds; *Lotus*, 34 seeds, several pods, and a green cutting; clover (mostly or entirely *Trifolium ciliatum*), 18 seeds, several leaves, and a head; godetia, 4 dry leaves; mouse barley (*Hordeum murinum*), 3 seeds; acorn of live oak (*Quercus wislizenii*), 3; green plants of spurge (*Euphorbia*), 2; pine nuts (*Pinus sabiniana*),

2; Australian chess seed (*Bromus arenarius*), 1; star thistle seed (*Centaurea*), 1; pinnacate beetle (*Eleodes*), 1; *Astragalus* green cuttings, several.

TABLE 2.—*Percentage of kangaroo rats in each month's sample having various foods in cheek pouches*

MONTH	SOFT CHESS	FESCUE	FILAREE	RED BROME	TURKEY MULLEIN	RIPGUT BROME	CLOVER	LOTUS
May	27.3	36.4	36.3	9.1	—	18.2	9.1	18.2
June	64.3	21.4	57.1	14.3	—	7.1	—	7.1
July	75.9	24.1	24.1	41.4	3.5	13.8	—	—
August	65.8	26.8	19.5	58.5	7.3	12.2	7.3	4.9
September	60.6	21.2	18.2	51.5	12.1	9.1	—	—
October	50.0	18.8	18.7	31.2	25.0	6.2	6.2	—
November	50.0	—	—	—	—	—	—	—

Actual numbers do not well express the relative importance of the several kinds. The seeds range in size from relatively large *Lotus*, turkey mullein, and ripgut brome through smaller soft chess to minute filaree and fescue. Frequency of occurrence is perhaps a better index. The percentage of animals in each monthly sample, having each important kind of food, is shown in Table 2. It is evident that, in this locality, soft chess is the most important food, with fescue, filaree, red brome, and ripgut brome somewhat less important, throughout the dry season. The late maturing turkey mullein assumes some importance in the fall. The records were distributed over three different years; nine in 1938, eighty-one in 1939, and sixty-two in 1940. Trends in different years were much the same in most respects, but nearly all of the turkey mullein occurrences were in 1940; in the unusually dry summer of 1939 this plant made poor growth and was scarce.

Further information as to the feeding habits in the dry season was obtained by sifting seed hulls from burrow mounds. Actual excavation of burrows, which might have provided better samples, was not practical on a large scale because of the cement-like consistency of the dry soil. The accumulated debris of seed hulls from food cached underground, and eventually eaten there, becomes mixed with the soil and occasionally, in cleaning out or extending its burrow, a kangaroo rat throws out finely pulverized soil well mixed with these hulls. Sampling consisted of first sweeping clean the burrow mound then sifting a sample of soil from the mound through a fine screen. The seed hulls and other plant materials were then sorted and counted. Samples were collected from thirteen different pastures which were subjected to different degrees of grazing intensity and were known to differ somewhat in their forage composition. In all, 264 different burrow mounds were sampled. They contained a total of 37,904 identified items from forty-two kinds of plants. The combined sample, although adequate, is subject to certain limitations. Some kinds of seeds may be hulled out before they are pouched. This applies particularly to lotus, lupine, turkey mullein, and sometimes filaree. Another drawback is the impossibility of dating the feeding. Only fresh burrow mounds were used, but the material in them may

have been used long before it was thrown out of the burrows. Table 3 shows the percentage of the total number of 37,904 items comprised by each kind of food plant, and the percentage of the 264 samples in which it occurred. Many other species were represented in small numbers. None made up more than one-tenth of one per cent of the total number of items, although some did occur in many of the samples, as shown by the following percentages: *Godetia* in 18.6 per cent; *Navarretia* in 11.0 per cent; *Cerastium* in 9.1 per cent; *Silene* in 8.7 per cent; *Pinus* in 7.2 per cent; *Lupinus bicolor* in 6.1 per cent; *Ceanothus cuneatus* in 5.3 per cent; *Micropus* in 4.9 per cent; *Centaurea*, *Plantago*, and *Brodiaea*, each in 3.4 per cent; *Avena*, *Gilia*, *Bromus arenarius*, and *Quercus* (acorn), each in 1.9 per cent; *Daucus* and *Agoseris*, each in 1.5 per cent; *Layia* and *Linanthus*, each in 1.1 per cent; *Bromus rigidus*, *Eremocarpus setigerus*, *Amsinckia*, *Thysanocarpus*, *Rhamnus crocea*, *Juncus bufonius*, *Trifolium*, and *Salvia*, each in less than .1 per cent.

TABLE 3.—*Relative abundance of seed hulls from different food plants in siftings from burrow mounds*

FOOD PLANT	PERCENTAGE OF TOTAL ITEM OCCURRENCES	PERCENTAGE OF TOTAL SAMPLES IN WHICH REPRESENTED
Bromus mollis (soft chess)	65.5	94.7
Erodium (filaree)	17.4	92.9
Bromus rubens (red brome)	6.4	67.7
Hordeum murinum (mouse barley)	3.0	45.0
Festuca megalura (foxtail fescue)	1.7	29.5
Plagiobothrys nothofulvus (popcorn flower)	.9	22.7
Poa (pine bluegrass)	.7	7.6
Lotus (lotus)	.7	27.7
Filago	.7	19.7
Chorizanthe	.4	4.9
Plantago	.2	3.4

Composition of siftings from burrow mounds agreed with that of cheek pouch contents in indicating that seeds of soft chess were the principal summer food, but it differed a good deal in some other respects. Fescue, which was second in importance in the cheek pouch contents, was scarce in burrow mounds. However, it was relatively scarce in the composition in 1940 when the siftings were collected, and nearly all cheek pouch records of it are from 1938 and 1939. Ripgut brome was meagerly represented in the burrow siftings, evidently because it was hulled before being taken underground. The similar scarcity of turkey mullein was due to the same cause and also to the fact that it ripened late in the summer after most of the burrow siftings had been made.

The burrow siftings were all made in May, June, July, and August, 1940. Differences in trends of some of the samples may result from differences in season. This may be brought out by percentages of different plants in the 11,842 items of the May-June sample compared with the 26,999 items of the July-August sample (Table 4). As in the cheek pouch records, it is indicated that

filaree seeds are used to a much greater extent early in the summer. Later, after release from the plant, they soon bore into the soil and are relatively inaccessible, while in soft chess the heads hold the seeds through most of the dry season.

TABLE 4.—*Changing seasonal percentages of different plant species occurrences in food (as indicated by burrow mound siftings)*

FOOD PLANT	PERCENTAGES IN MAY-JUNE SAMPLE	PERCENTAGES IN JULY-AUGUST SAMPLE
Soft chess	47.0	71.0
Broadleaf filaree	32.5	9.8
Mouse barley	7.3	1.0
Red brome	3.7	7.3
Popcorn flower	2.2	.3
Pine bluegrass	2.2	—
Lupine	1.7	.3
Filago	1.2	.4
Fescue	.1	2.4

TABLE 5.—*Percentages of different plant species in total forage yield and in kangaroo rat food, compared for two areas*

FOOD PLANT	HEAVILY GRAZED PASTURE		PROTECTED PASTURE	
	Percentage of forage yield (dry weight; average of 1937 and 1945)	Percentage of kangaroo rat food items (from burrow siftings)	Percentage of forage yield (dry weight; average of 1937 and 1945)	Percentage of kangaroo rat food items (from burrow siftings)
Soft chess	20.5	68.6	31.5	76.4
Broadleaf filaree	34.0	19.8	10.3	2.8
Red brome	2.4	6.3	2.6	15.8
Foxtail fescue	15.1	1.3	11.5	1.6
Other	28.0	4.0	44.1	3.4

To determine the effect of varying forage composition and grazing intensity on the feeding of the rats, comparison was made between the two most dissimilar pastures of the Range. One of these was "Pasture 3" stocked with one head of cattle to ten acres during eight months of the year, and with utilization graded as "Close" or "Very Close" during the five years of controlled grazing intensity preceding the collecting of the sample. It was contrasted with the "Natural Area" which had been protected from grazing since 1934. There were noticeable and measureable differences, produced by the difference in treatment, in the relative abundance of the different forage species on these two areas. On the Natural Area, grasses, including soft chess, were dominant. On the heavily grazed pasture, broadleaf forbs of low growth habit and rosette form were encouraged by the removal, through grazing, of the forage crop. Broadleaf filaree, especially, was increased and was the dominant forage species. The composition for the four principal forage species from twelve burrow samples, with 3791 items, from Pasture 3 and sixteen burrow samples, with 3951 items, from the

Natural Area is shown in Table 5. It is indicated that soft chess made up the greater part of the food on both areas, but that filaree, where very abundant, partially replaced grasses in the diet.

Burrow siftings and cheek pouches afford a fair idea of the food composition in the entire dry season, but the less adequate data available for winter and spring indicate a shift to other food sources for those seasons. Of the 125 winter burrows excavated, nine (all in January) contained food consisting *in toto* of: 3840 leaves and 4 entire plants (rosettes) of filaree, 523 grass leaves (333 *Hordeum* and *Bromus*, 190 *Festuca*), 270 pine nuts, 188 red maid leaves or cuttings, 125 popcorn flower leaves, 31 miner's lettuce (*Montia*) leaves, 25 lotus leaves, 11 toad-rush leaves, 6 acorn hulls, 1 lupine leaf. For five of the caches with 3840 of the 5024 items, weight percentages were as follows: filaree 94.5 per cent, grass and red maids each 2.0 per cent, popcorn flower 1.5 per cent. For the entire winter sample, filaree made up 90 to 91 per cent of the weight, pine nuts were calculated at 5.5 per cent, with the remainder made up of grass, red maids, and popcorn flower in that order.

A slight amount of additional data is provided by the cheek pouch contents of a few winter collected kangaroo rats. In four, taken in December, there were: red brome, fourteen green leaves in four different animals; soft chess, seven leaves in one animal; filaree, nine leaves in one animal; and pine nuts, two in one other. The two recorded as having pouched food in January each had filaree leaves numbering eighty-four and twelve respectively. One in February had pouched several styles of filaree. One in March had three leaves of ground lupine and seventeen seed capsules of chick weed (*Stellaria*). In winter, apparently, there is a change in diet from seeds to green foliage material, mainly of filaree.

Quantitative data are lacking for the feeding during spring, and it may be that the rats exert most of their effect on the forage crop at that period. Clues are provided by miscellaneous observations. In March, 1938, it was noticed that a single soap plant (*Chlorogalum*) growing in the kangarro rat enclosure was heavily grazed by the animals, but closer inspection was necessary to find evidence of their use of the other vegetation. Cuttings of popcorn flower were found in some of the burrow entrances. Evidently the leaves and stalks had been eaten, but heads were discarded. In March and April, small heaps of filaree fruits, from which the seeds had been stripped, were accumulating about burrow entrances and along surface trails and apparently were the favorite food. It is much more difficult to trap kangaroo rats at this season than at other times. Adult rats of both sexes attain maximum weights then and many of the females are gravid. Filaree seeds constitute a nutritious and easily obtained food source which is preferred to grain baits. In late April and early May, grass seeds are maturing and are harvested in quantity. Often the seeding heads are cut entire. Occasionally, at the ends of runways leading from burrow entrances into thick vegetation, piles of soft chess heads (a pint or more each) have been found. These may be left to cure above ground or may be merely an excess at this season of abundance. At times, along kangaroo rat trails, both in the enclosure and on the open range, grass stalks (soft chess, fescue, or

red brome) have been found cut in quantity and left lying with the seed heads intact. Such cutting evidently results from a tendency to keep trailways and foraging areas clear of obstructing vegetation which might prevent rapid passage. These kangaroo rats prefer situations with sparse vegetation. During the period of weeks in spring when most rapid forage growth occurs, their movements are somewhat hindered by the profusion of stems and foliage.

Tappe (*op. cit.*: 125–26) was of the opinion that this rodent causes but little economic loss on range lands. He stated: "If every bit of forage produced were needed by livestock, then the cutting of some of the available green forage and the harvesting of seeds by kangaroo rats might affect the carrying capacity of the area for livestock enough to make the rats of adverse economic importance. If so, the competition offered by kangaroo rats would seemingly increase as the acreage necessary to support each head of livestock increased on an overgrazed area. On a properly grazed range it is unlikely that the rats would decrease the carrying capacity of the range for livestock."

It should be mentioned in this connection that on California ranges of annual type forage (mixed filaree, soft chess, red brome, and foxtail fescue) heavy grazing intensity is economical and does not result in an undesirable alteration of the forage composition. An important factor is the unpredictable and wide fluctuation in the forage yield from year to year determined by the uncertain quantity and distribution of rainfall. In consequence, the stockman is unable to regulate his herd from year to year, to obtain optimum utilization, and is periodically hard pressed to maintain his livestock in dry years when feed is short. At such times some "overgrazing" of the available forage is unavoidable and the competition between livestock and rodents is intensified. A high kangaroo rat population might take a substantial portion of such a short forage crop and thereby cause heavy financial loss.

An adult male kangaroo rat, kept in captivity and fed upon weighed amounts of food over a thirty-day period, consumed an average daily food weight of 4.94 grams (dry weight) along with a moisture content of 2.64 grams. The food consisted of rolled oats (136 grams, 10 per cent moisture) and filaree rosettes (109.1 grams, 75.5 per cent moisture). When fed for a week on rolled oats exclusively, the animal lost weight (from 62.2 grams to 51.5 grams), but this was quickly regained when the moisture-containing filaree was furnished. On the basis of the feeding of this one individual, it is estimated that the annual food requirement of a kangaroo rat would be about four pounds dry weight and the high population of thirty-two per acre, represented by the enclosure experiment, would take 128 pounds annually. Even this amount is but a small percentage of the usual forage crop and would scarcely have measureable effect on livestock production. Evidently, however, the amounts actually eaten by kangaroo rats are much less than the amounts otherwise destroyed by them. The potential destructiveness is brought out by the effect on the forage yield in the quarter acre enclosure where eight were kept, representing a population of thirty-two per acre. An adjacent control enclosure, protected from all animal use, served as a standard of comparison. Both were sampled by clipping, drying,

and weighing 100-foot-square quadrats at the height of the growing season in four different years (1940–43). These enclosures, after being protected from animal use, were similarly sampled at the end of each growing season in 1946 and 1947. These latter measurements indicated that under non-use the kangaroo rat plot and the control were equally productive (combined yield for the two years approximately 1039 pounds in each plot). But each year in which the rats used the vegetation in the former plot, its yield was several hundred pounds per acre (dry weight) less than that of the control, indicating the destruction of 11.6 pounds of forage on the average for each kangaroo rat in the course of the seven months growing season. The thirty-two kangaroo rats per acre reduced the yield by an amount from 13.1 per cent to 15.5 per cent of the total during the growing season of about seven months. This reduction in yield amounts to a quantity more than three times as great as the rats probably would have eaten. Much of this damage is evidently caused by the stunting effect of eating back plants early in the growing season and of cutting and discarding, or storing underground, quantities of vegetation that are not used as food. On the open range, in competition with livestock, the damage by each rat would be less; the stunting effect of their eating and trampling would be small compared with that of cattle or sheep. The destruction in the enclosure may be paralleled on grazing areas which are reserved for intensive use at the height of the growing season or during the dry season. Under such conditions, use by kangaroo rats and other rodents throughout the process of growth would deplete the yield later available for stock. Not all the forage weight eliminated by kangaroo rats would be available otherwise to grazing livestock; some of it would be destroyed by their own trampling, some would consist of excess cast seeds or parts growing too close to the ground to be accessible, and some would consist of plant species unpalatable to stock. In this last category would be included turkey mullein, spurge, and pine nuts. But all available evidence indicates that, throughout the growing season at least, the principal forage species used by livestock also provide most of the food of the kangaroo rat. It must be added that the population density represented by the enclosure is unusually high for the area of the Experimental Range at least. In normal years, as represented by those in which trapping censuses were made, a forage loss of one-fourth to one thirty-secondth of that sustained in the enclosure could be expected.

In correlation with its ability to carry food in its cheek pouches, and its storing habits, this kangaroo rat has a small stomach capacity as compared with other rodents. In nineteen, which were snap-trapped or gassed in November, December, and January, the stomachs and their contents averaged 2.14 per cent of the total weight. They varied from .8 per cent to 3.3 per cent in different individuals. Kangaroo rats kept in confinement had no well defined feeding periods, but nibbled at frequent intervals throughout the day and night.

BAITS

Field tests of many kinds of baits were made at different times of year. The bait usually used for live-trapping was a mixture of milo maize and wheat.

This was generally more attractive than the available natural foods. In contrast, corn, rice, and whole or rolled barley were taken sparingly or not at all. Rolled oats were preferred even to wheat and milo, but were not used in routine trapping because they were also preferred by insects and were apt to be removed in a short time by harvester ants. Peanut butter was not taken. Dry filaree seed, though an important natural food, was much lower on the scale of preference than were most of the cereals. In a test made in August, 1939, bur clover, purple vetch, domestic rye grass, and alfalfa seeds—in that order—were all preferred to rolled oats. The order of preference of various baits was not found to change seasonally, but bait acceptance in general changed a good deal from night to night. On bright moonlight nights the catch was apt to be much less than on dark nights, other things being equal. Through most of the year, the number of kangaroo rats caught per hundred traps set per night varied from fifteen to twenty-five, but during a period of weeks from late March to early May it often decreased to five or less per night.

POPULATION DYNAMICS

Live trap census.—Kangaroo rat populations are subject to marked fluctuations. During the eleven-year period from 1935 through 1946, for which records of various sorts are available at the Experimental Range, a reduction from perhaps thirty per acre to only one per acre is known to have occurred, but, due to interruptions in field work, the time, manner, and cause of the decrease are not definitely known.

Live-trapping operations on the eighty-acre area served as a basis for population investigations. Computations of total numbers present were based on the ratio, among those caught in a given period, of repeats from an immediately preceding period of the same length. Sampling periods needed to be sufficiently long to cover the area thoroughly and to obtain representative numbers of each group, yet short enough to avoid large margins of error that might arise from population changes within and between sampling periods—changes brought about by death and/or movement to and from the area. A two month sampling period was considered most satisfactory for this purpose. The total July-August population, for instance, was calculated from the number caught in this period, the number caught in the September-October period, and the ratio to them of repeats taken in both periods: Expressed as an equation:

$$\frac{\text{July–August population}}{\text{Number actually caught in July–August (149)}} = \frac{\text{Number caught in September–October (250)}}{\text{Number caught in July–August and again in September–October (95)}}$$

$$\text{July–August population} = \frac{149 \times 250}{95} = \frac{37250}{95} = 392$$

A similar computation for the August-September population was 396; from the average of these two overlapping periods, the August population was derived

(394). For each month in 1939, 1940, and 1941, values obtained by this method are shown in Figure 1.

The figure obtained in each monthly census is believed to be somewhat higher than the actual number present because each sample probably included a certain percentage of individuals having home burrows in peripheral areas. The margin of error to be expected from this source is difficult to estimate because the home range, or cruising radius, varies so much that it cannot be well defined with the data at hand. However, it is evident that most of the foraging is done in proximity to the burrow. The fact that 54.5 per cent of all those recaptured were recorded within areas 100 feet or less in diameter seems to indicate that the percentage of peripheral invaders in each sample is not large. Perhaps 10 per cent, almost certainly less than 20 per cent, of those trapped came from outside the area. The population density therefore would be correspondingly lower than the figures obtained.

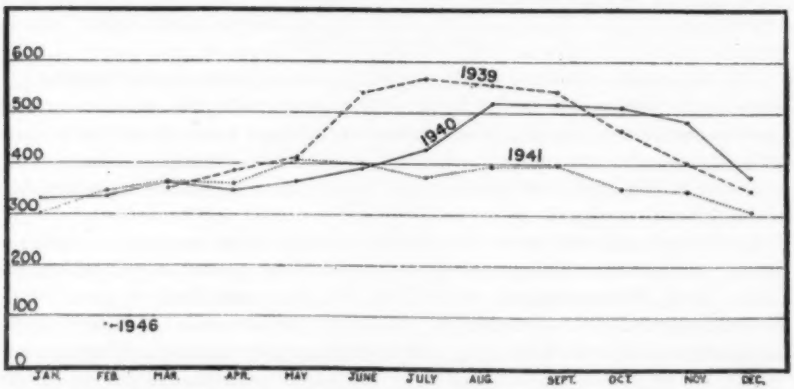

FIG. 1.—Month to month changes in numbers of kangaroo rats on an eighty-acre area

For this three year period it is noteworthy that the numbers do not follow any definite seasonal pattern or trend through the annual cycle, except that minimum numbers occur during the winter months, when breeding activity has nearly ceased, and a gradual increase is noted during late spring, summer, and early fall. Breeding was unusually early and successful in 1939. By June, the numbers of early spring had increased by 50 per cent. In 1940, there was a similar, but smaller, increase several weeks later. The summer gain was slight in 1941. A clue to the reason for the varying time and success of increase is provided by the weather records; drought conditions evidently favor the species. In 1939, the spring months were unusually dry and warm. There was a rainless period from the first week in February until mid-March, two rains in the latter half of March, and none during April and May. The total rainfall for the season was 12.25 inches. In 1940, there were rains throughout most of February and late March with a season total of 21.22 inches. In 1941, there were heavy rains

through February and early March and more than 4 inches in April, with a season total of 28.33 inches. Cold and wet weather during the early part of the breeding season may be an important factor. The soil in the shallow and poorly constructed burrows becomes damp or even saturated in rainy weather, and early litters may often be destroyed during heavy rains in March or April.

The high population of kangaroo rats in 1935 and 1936, on the Range, came at the end of a series of dry years. The reduction to only one per acre in 1946 occurred during a series of years of unusually heavy precipitation. The geographic range as a whole is in more arid regions where annual precipitation may amount to only a fraction of that at the Experimental Range. It seems likely that in the latter locality, rainfall, and perhaps the resulting density of annual vegetation, may be the critically limiting factor in the ecology of the kangaroo rat.

Road counts.—Night road counts by automobile provide a basis for gauging the relative population densities in different areas. In May and June, 1940, on the eighty-acre trapping area with its population of between four and five per acre, 189 kangaroo rats (about two and three-tenths per mile) were counted in a total of 739 minutes of driving at ten miles per hour. Counts were made under conditions favorable to kangaroo rat activity, in the early part of the night and during nights when there was not bright moonlight. An attempt was made to census the Range as a whole by driving through all the pastures and making night counts for comparison with those made on the live-trapped area under similar conditions. The purpose was to correlate numbers with grazing intensity on different areas, but it was soon evident that other factors were more important. The roads were in all instances in better drained parts of the pastures, tending to follow ridges, in the more favorable kangaroo rat habitat, so that no route taken could be considered representative of a pasture as a whole. Also the rats are attracted to dirt roads, which provide open runways and dusty places for wallowing. On roads of pastures one to ten of the Range, there were 1.42 minutes of driving per rat, indicating a population density of 275 per cent of that of the trapping area—perhaps fourteen per acre for limited areas along the ridges which the roads followed.

As might be expected, counts made at different times over the same area were variable. Tappe (1941: 128) found that these rats usually emerged twenty to thirty minutes after sundown on moonless nights and were active above ground for about forty minutes, further, they usually emerged for a shorter period of activity later in the night. His conclusion that activity was greatest in the early part of the night, and that moonlight limited the activity, were corroborated at the Experimental Range. On the night of September 5, 1939, for example, a route was covered four times and the following counts were made: 9:19 P.M. to 10:45 P.M., twenty-nine; 10:46 P.M. to 12:08 A.M., eight; 1:07 A.M. to 2:19 A.M., five; 3:02 A.M. to 4:05 A.M., one. The moon rose at 10:39 P.M.; on this and other occasions it appeared to be an important controlling factor. Wind and low temperature also are factors which apparently tend to reduce activity (Table 6).

In 1935, and 1936, before the present study was begun, kangaroo rats were so much more abundant that the numbers seen on roads at night attracted much attention. Only one definite figure is available: Everett E. Horn made a count of seventy-two on the two-mile stretch of road between headquarters and the west boundary. Kenneth A. Wagnon, though recording no definite counts, was much impressed by the numbers, and on one occasion in particular, in early evening just after a warm fall rain, saw kangaroo rats fairly swarming on roads illuminated by the automobile headlights; dozens were seen for each mile of driving.

In 1935–36, under optimum conditions, apparently as many kangaroo rats could be seen in a few minutes of driving at night as were counted in many hours

TABLE 6.—*Variation in counts obtained over the same route, but at different times and under various weather conditions*

DATE (1940)	TIME	WEATHER	NUMBER OF KANGAROO RATS
May 8.....	10:08 to 11:20 P.M.	no moon, 60°F.	54
May 9.....	1:03 to 3:33 A.M.	no moon, no wind, 58°F.	68
May 10....	8:53 to 11:18 P.M.	moon, in first quarter set 9:21, 60°F.	67
May 11....	8:47 to 10:26 P.M.	no moon, 66°F.	54
May 12....	8:58 to 10:46 P.M.	overcast, windy, 64°F.	28
May 15....	12:33 to 2:07 A.M.	moon in second quarter, no wind, 62°F.	94
May 16....	8:24 to 10:08 P.M.	overcast, no wind, 72°F.	31
May 17....	8:08 to 10:00 P.M.	moon, partly cloudy, no wind, 62°F.	24
May 20....	8:37 to 10:25 P.M.	full moon, no wind, 74°F.	17
May 21....	8:52 to 10:45 P.M.	full moon, no wind, 68°F.	36
May 24....	8:16 to 10:23 P.M.	no moon, light wind, 57°F.	23
May 27....	9:05 to 10:47 P.M.	no moon, cold, light wind, 53°F.	27
May 28....	8:41 to 10:24 P.M.	no moon, cloudy, no wind, 57°F.	19
May 29....	9:05 to 10:46 P.M.	no moon, no wind, clear, 50°F.	48
May 30....	8:39 to 10:18 P.M.	no moon, no wind, clear, 60°F.	31
May 31....	9:11 to 10:53 P.M.	no moon, no wind, partly cloudy, 60°F.	15

in the early summer of 1940. Despite the great variation in time and extent of activity influenced by a complex of factors having to do with weather conditions, road counts should provide an excellent index to the relative population densities in different areas when adequate samples are available. At a time and place where the population is extremely high, a comparatively small amount of driving soon after nightfall, in the dark of the moon, would be necessary to obtain a sample, but where the population is sparse, many hours of driving would be required to obtain even an approximate population density estimate.

Reproductive potential.—The present species demonstrates a high rate of reproduction which is far surpassed among rodents only by the murine and microtine species which are the classic examples of high reproductive potential. Female kangaroo rats of between 30 grams and 40 grams in weight, and probably less than two months old, show evidence of oestrus. Some young are known to

have produced two successive litters in the same breeding season during which they themselves were born. Adult females undergo oestrus repeatedly after having produced litters. They are probably capable of producing at least three litters during a breeding season. At this rate, an original female might have thirty or more progeny by the end of the breeding season in the fall, if litters averaged three.

Tappe (1941: 146) states that "The number of embryos varies from two to five, with an average of 3.7." The size of the sample is not mentioned, but presumably the statement is based on a large number of counts from specimens in the Museum of Vertebrate Zoology. In the present study an inadequately small sample of only fourteen litter counts was obtained, nine with three young and five with two young, an average of 2.64 per litter. In four instances the counts were based on litters born in traps after the females were caught and there was some chance that other young had been born prior to capture of females. Two of the trapped females had three young each and two had two each.

Dale (1939: 715) found an average of 2.65 embryos in twenty pregnant females of the subspecies *saxatilis*. He suggested that litter size is larger in the spring at the height of the breeding season; eleven sets of embryos in April and May averaged 3.1 per set, while nine sets occurring in other months averaged 2.1.

Limitation of habitat, intraspecific intolerance, and the toll of unfavorable weather conditions, disease, and predators prevent the potential increase from being even approximated. In fact, on the eighty-acre trapping area the population was remarkably stable as compared with that of the ground squirrel which made sudden large gains at the season of emergence of the single annual crop of young. The kangaroo rat population contained a high proportion of animals of adult size at all seasons, though in late summer and fall these were largely recently matured young of the current season's litters. As shown in the discussion of growth, about six or seven weeks are required from the time the rat is large enough to leave its burrow and forage for itself until it reaches small adult size. As this period of growth is a relatively short part of the life cycle, partly grown young comprise only small percentages of the population except after the peak of the breeding season. Table 7 shows something of the relative numbers of growing young and of adults (or subadults) from month to month; it is based on all kangaroo rats for which weight records were obtained in 1940 and 1941. The young recorded for each month represent, for the most part, successive increments to the previous population which, however, made only slight net gains from month to month during spring and early summer and was on the decline after September in both years. The young captured averaged more than half-grown and may have averaged around six weeks old. They were apparently the progeny of matings that occurred from two to three months previously. For instance, the 1940 peak of 79.6 per cent young in July represents mostly March and April breeding.

Individuals which have recently attained adult size are often still recognizable as young by their pelage. In part of the 1940 season, those classified as young on the basis of size or pelage or both comprised the percentages of the total number of captures shown in Table 8.

Breeding.—Information on individual females is not sufficiently complete to show the breeding record of any one of them for an entire year, but there is

TABLE 7.—*Percentages of partly grown kangaroo rats (less than 50 grams) in month to month samples of those trapped*

MONTH	TOTAL NUMBER WEIGHED		PERCENTAGE LESS THAN 50 GRAMS	
	1940	1941	1940	1941
January	39	144	none	none
February	67	137	none	none
March	65	130	3.1	8.5
April	25	48	4.0	2.1
May	70	115	41.5	22.5
June	12	55	41.6	20.0
July	49	75	79.6	14.6
August	194	91	29.4	14.3
September	184	164	21.8	18.3
October	178	187	9.5	18.7
November	153	254	11.1	18.9
December	53	121	7.5	14.0

TABLE 8.—*Percentages of young kangaroo rats, 1940 season*

DATES	MARCH 1–15	MARCH 16–31	APRIL	MAY 1–15	MAY 16–31	JUNE 1–15	JUNE 16–30	JULY 1–15	JULY 16–31
Percentage of young	1.0	0	2.9	34.6	50.0	44.6	55.0	57.4	67.7
Total number of captures	104	6	35	81	90	161	149	115	220

TABLE 9.—*Month to month percentages of non-breeding female kangaroo rats*

MONTH	TOTAL NUMBER RECORDED	PERCENTAGE OF NON-BREEDERS (IMPERFORATE AND NOT NOTICEABLY GRAVID OR LACTATING)
January	114	96.4
February	123	82.1
March	108	30.6
April	14	28.6
May	70	31.4
June	84	35.7
July	82	44.0
August	94	64.2
September	156	78.2
October	239	79.5
November	373	93.1
December	205	90.2

evidence of multiple litters annually. The course of the breeding season could be traced from the appearance of external genitalia in live-trapped females. In non-breeding females, those not sexually mature and those sexually quiescent,

as were nearly all in midwinter and varying percentages at other times of year, the imperforate condition prevailed with the vaginal canal sealed off from the exterior by a layer of thin semi-transparent skin through which the pinkish vaginal wall could be seen faintly. In those apparently entering oestrus, the area about the clitoris was slightly discolored and swollen and the vaginal canal opened as a transverse slit about 2 mm. wide, its lips closely adhering. The vaginal lining at this stage was thin, moist, and pinkish. Subsequently, over a period of days, the lips of the vaginal orifice enlarged and thickened and became corrugated with longitudinal folds. The orifice itself enlarged to from 5 to 10 mm., and the vaginal wall became thickened, dry, and whitish. This was followed by a shriveling of the enlarged parts and a sloughing of the thickened layers of tissue with gradual regression to the imperforate condition by close

PLATE I

Litter of kangaroo rats, one day old

adherence of the vaginal lips and their overgrowth with a layer of thin skin. This cycle begins in young which are hardly more than half grown; it is often seen in those which have reached a weight of about 40 grams and occasionally, at least, in smaller ones. For instance, one caught on May 8 weighed only 30 grams and was perforate with genitalia swollen; on May 13, it weighed 38 grams and was imperforate and on May 17, it weighed 39 grams and was again perforate, with swelling. No actual pregnancies were recorded in these young, but pregnancy was difficult to recognize except in its late stages.

The general trend of the breeding season is shown by the ratio of those in oestrus, pregnancy, or lactation to imperforate non-breeders, in different months. Table 9 includes all females for which such data were recorded. Data for four different years, the fall of 1939, all of 1940 and 1941, and January 1942, are

combined. Breeding is almost, but not quite, discontinued during November, December, and January and increases to a peak in April. It then gradually tapers off through the summer months.

Males are apparently slower to reach sexual maturity. Those below the size of small adults, 50 grams, nearly always had small abdominal testes. In November and December testes were small, usually abdominal, even in large adults. In January and February testes enlarged and descended into the scrotum. In March and April nearly all males had much enlarged scrotal testes and appeared to be at the peak of breeding condition. Many of the larger males appeared to

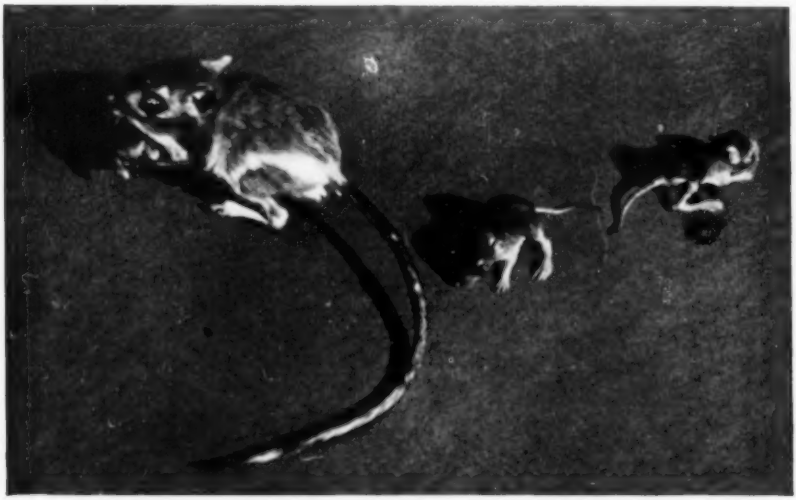

PLATE II

Female kangaroo rat with young, eight days old

be in breeding condition throughout the dry season; others, often smaller ones, had the testes less developed or even abdominal.

Mating behavior apparently is delicately adjusted to the social habits as well as to the physiological condition of the animals. The observations of Allan (1944) on *Dipodomys ordii* in captivity suggest that mating occurs on neutral ground rather than in the burrows and that it is associated with the dust bathing habit. In their underground lives, kangaroo rats are solitary, so far as is known, and jealously defend their burrows against others of their species. Those caged together were generally hostile, sparring, biting, and kicking at others that came near. Females were less generally aggressive and sometimes became accustomed to others so that they shared the same nest without fighting, but weaker ones were apt to be attacked and killed at any time. A litter of young successfully reared in captivity eventually killed and partly ate the mother.

Even those which appeared to be in breeding condition usually showed no sexual behavior when confined together. An exception was a captive male, which mated several times with different females placed in its cage. Females with

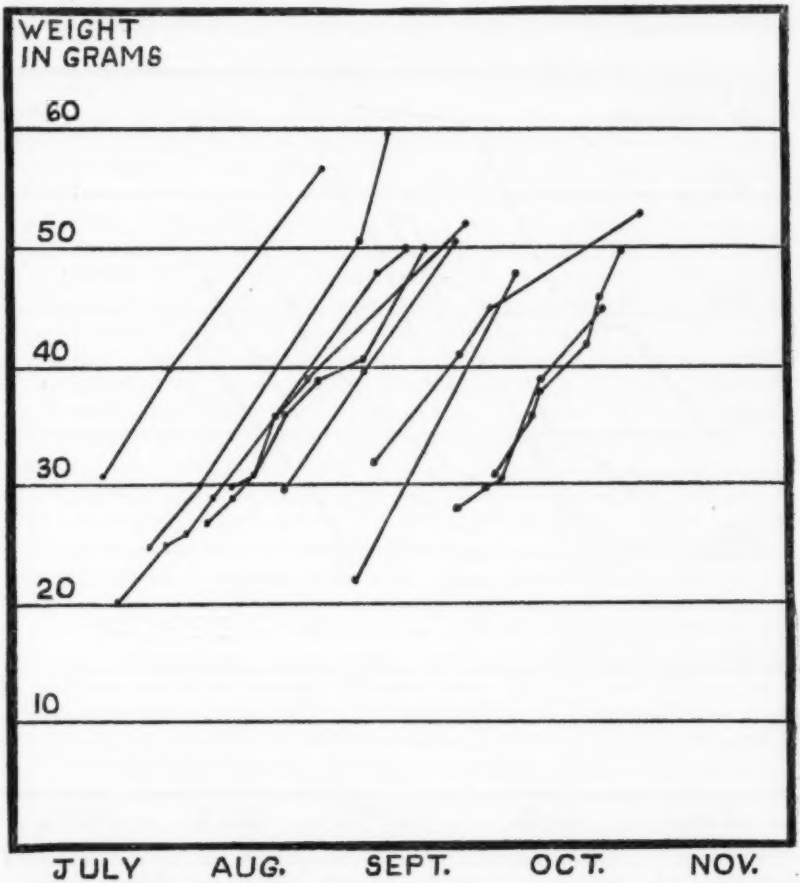

FIG. 2.—Weight gains in individual kangaroo rats; young males in late summer and fall, 1940.

enlarged and thickened genitalia were definitely hostile and unreceptive and elicited no interest on the part of the male. Those that mated were recently perforate. Scent evidently played an important part. Mating was preceded by several minutes of following the female about the cage and nosing her genitalia in apparent excitement. Often, after the male had mounted, prolonged attempts at copulation were unsuccessful and ended in the female's escaping. Most of

the females placed in the cage were hostile and reacted by taking the defensive; they were then given no further attention by the male even though they appeared to be in breeding condition.

Growth.—Tappe (1941) has given an excellent detailed account of the early development of a litter of young born in captivity. He stated that the four

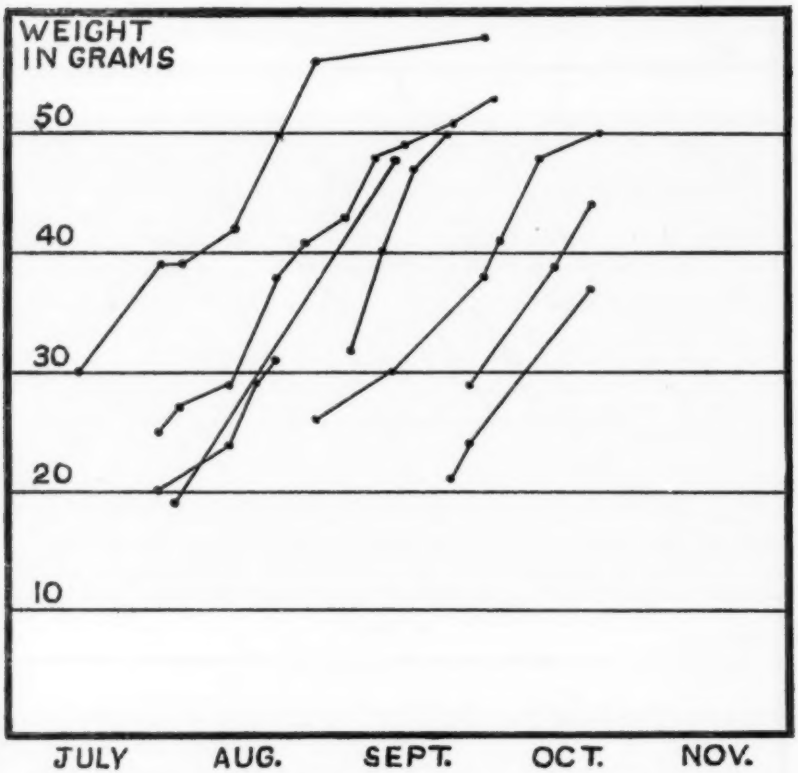

FIG. 3.—Weight gains in individual kangaroo rats; young females in late summer and fall, 1940.

young of this litter weighed 3.4, 3.5, 3.8, and 3.9 grams, and that newborn young averaged only one-twentieth the weight of adults. In the present study, newborn young of several litters weighed as much as 5 grams, about one-twelfth of the average adult weight (60 grams in this locality). Tappe (*op. cit.:* 142) stated that "Weaning appeared to be a gradual process that began when the young first started to take solid food on the seventeenth day and ended on the twenty-fifth day."

In the present study (Plates I and II), a litter of three young, born in captivity, began to have their eyes open on the twelfth day, and on the fifteenth day all eyes were open. At twenty-three days they fed greedily on lettuce when it was offered; they had well developed incisors and cheek teeth were just piercing the gums. They pouched grain at twenty-four days. At twenty-five days their cheek teeth were well developed and their appearance was similar to that of the smallest young trapped in the field; the larger of the two survivors equalled these in size and weight. These young may have been somewhat stunted by captivity. Tappe was of the opinion that the young do not leave the burrow until six weeks old. He stated (*op. cit.:* 144) that "The youngest appearing individual taken by me weighed 24.3 grams, but one specimen of *tularensis* in the Museum of Vertebrate Zoology weighed only 23.5 grams. . . . No record is known to exist of a smaller specimen than this being taken in traps." In the present study, however, smaller ones were trapped; some caught in 1940 weighed 22, 21, 20, 20, 19, and 18 grams, respectively. Young probably begin to forage for themselves, and perhaps seek new burrows, at or slightly before the age of four weeks. Those in captivity were weaned by the twenty-fifth day and, though perhaps stunted by confinement, were then as large as some trapped in the field. There seems little likelihood that in the course of normal development young would remain underground much beyond the time of weaning.

Subsequent growth is well shown by the records of many that were marked and weighed as small young and recaptured once or many times before they had attained adult size (Figs. 2 and 3). In 1940, many such young, trapped, marked, and weighed while in the 20 to 30 or the 30 gram to 40 gram weight classes, were retrapped and weighed repeatedly. There were forty-one males in this group, which were used to compute average daily gains at different stages of growth: from the 20–30 to 30–40 gram group; 30–40 to 40–50; 20–30 to 40–50; and other combinations. Gains varied a good deal in different individuals and in the same individual between different dates. For the better series, gains averaged about .6 grams daily in each animal up to a weight of 50 grams, the size of a small adult Growth was only a little more rapid in the smaller ones. At this rate of growth, the following schedule of development may be taken as typical: birth to four weeks, up to 25 grams; four to eight weeks, 25 to 40 grams; eight to ten and one-half weeks, 40 to 50 grams. As the young less than a month old spend nearly all of their time underground, and are seldom trapped, there is an interval of only six or seven weeks in which trapped young are recognizable as such.

Longevity.—Records of individuals indicated that the usual life span is short, as might be expected in an animal having such a high reproductive potential. In the four years of trapping, involving the handling of 2106 kangaroo rats on the eighty acres, only 4.7 per cent of those taken had records extending over more than a year. Of all those taken, 35.2 per cent had records extending over not more than one month and 34.2 per cent had records extending from one to six months. Thus, less than one-third had records of more than six months on this area. In many instances disappearances may have been due to movement

elsewhere, but it is probable that more often death was the cause. Only one kangaroo rat had a trapping record that extended over more than two years; this one, a male, survived for thirty-three months after it was marked as a partly grown juvenile. On the average, those marked as young had essentially the same survival expectancy on the area as did adults. Males and females did not differ measurably in their survival expectancy.

Natural enemies.—This species of kangaroo rat is an important food source to many kinds of predators because of its abundance and year-round availability. For some of these, such as the badger (*Taxidea*) and bobcat (*Lynx rufus*), the relationship seems probable, but is a matter of speculation. For others, numerous records were obtained showing something of the extent of their predations.

The rattlesnake (*Crotalus viridis*) was recorded as preying upon kangaroo rats many times in this locality. Kangaroo rats occasionally found dead in the field had, in most cases, been bitten by rattlesnakes. A half-grown rat found dead on June 2, 1938, had its fur matted, apparently by a small snake which had failed in the attempt to swallow it. Another, found on June 22, 1938, had been bitten in the left shoulder where there was extensive hemorrhage. A young one, found dead in a surface runway on June 7, 1939, had been bitten and its pierced thoracic cavity showed internal hemorrhage. An adult female, found dead on July 10, 1939, had been bitten in the thigh. A young female, found on August 28, 1940, had been bitten on the left side and its body cavity was pierced. In most of these instances, the kangaroo rat, after being struck, probably ran too far to be found and eaten by the snake. On one occasion a rattlesnake was seen to trail a kangaroo rat, which had been bitten, to where it lay dead in the road. It seized the rat and, apparently to escape the high temperature in the open, dragged it several yards to the shade of a bush before swallowing it.

Among 285 food items of rattlesnakes recorded, mostly from 1938 to 41, there were thirty-two occurrences of kangaroo rat. Second in frequency among the nineteen prey species, it was computed to amount to 5.5 per cent of the food weight of all recorded prey. Ground squirrels (*Citellus*) made up about 69 per cent. A critical examination of these data indicates that kangaroo rats make up a much greater part of the year round diet. Most of the feeding records, 193 of the 285 total, were obtained by making stomach examinations on snakes. Seventy-four per cent of these were taken in March, April, and May, the spring season when rattlesnakes are still diurnal and feed principally on diurnal prey—young of ground squirrels and cottontails (*Sylvilagus*). Rattlesnakes are almost entirely nocturnal in their prowling from early June through the dry season and hence were rarely taken. After early June the young of ground squirrels and rabbits, which make up more than 85 per cent by weight of the spring food, have grown too large to be swallowed by most rattlesnakes and are no longer available. In this latter two-thirds of their active season, rattlesnakes may turn to kangaroo rats as their principal food source. A series of ninety-two rattlesnake scats collected in summer—representing, in part, feeding during months of nocturnal activity and, in part, spring feeding—showed trends of composition markedly different from the stomach examinations representing

almost entirely the spring season. Kangaroo rats comprised 26.7 per cent of the items in the scats while in the 179 stomach items they comprised only 5.8 per cent. It should be explained that in both samples, especially those from stomachs, food of the small young snakes (mostly lizards and mice) made up a considerable proportion of the total items, but only a small part of the total food bulk. When young ground squirrels and cottontails have grown too large to be eaten, in early summer, kangaroo rats, pocket gophers (*Thomomys*), and possibly woodrats (*Neotoma*) comprise the only evident food sources of sufficient numbers and suitable sizes to sustain the adult population of rattlesnakes. The pocket gopher, however, is evidently less active and less inclined to surface foraging in the dry season; it is then relatively safe from snake predation. Its percentage in scats (2.22 per cent) was even smaller than in stomachs (9.2 per cent). Woodrats were much less frequent than kangaroo rats in both samples.

The rattlesnake population of the Experimental Range, intensively sampled by marking and releasing on a 160-acre area, was computed at .6 snakes per acre, with an annual food requirement of perhaps about 240 grams (or .53 pounds) per acre. If, as seems probable, half of this food weight is made up of kangaroo rats, then two adults or a larger number of immature ones would be required.

There was only one kangaroo rat among seventy-two gopher snake food items. Among 1924 vertebrate prey items in coyote (*Canis latrans*) scats, kangaroo rats were third in frequency with 361 occurrences, computed to make up 3.3 per cent by bulk of the diet. There was at least one horned owl (*Bubo*) to one hundred acres on the Experimental Range. In 1565 prey items from pellets and nests there were 219 kangaroo rats, computed as 4.5 per cent of the food weight. Their annual toll of the kangaroo rat population would approximate that of the coyote—one per two acres. Barn owls (*Tyto*) are much scarcer locally and their predation would not be an appreciable factor; among 517 pellet prey items there were thirty-five kangaroo rats. Even the red-tailed hawk (*Buteo*) catches kangaroo rats, though probably in trivially small numbers. Among 625 nest prey items of the hawks there were ten kangaroo rats; among 4036 pellet prey items there were thirty-four. Among 102 prey items identified in gray fox (*Urocyon*) scats, seventeen were kangaroo rats, computed as about 4.1 per cent of the food represented.

These several predators are the ones responsible for most instances of predation on the kangaroo rat, but other smaller forms probably take them in small numbers—weasel (*Mustela frenata*), striped skunk (*Mephitis*), screech owl (*Otus asio*), and short-eared owl (*Asio wilsonianus*). Even ground squirrels have been seen carrying or eating kangaroo rats that they either caught and killed or found dead.

The data presented above indicate that the rattlesnake is locally by far the most important predator of the kangaroo rat, and probably one of the principal natural enemies over the entire range. Unknown variables prevent the calculation, with any degree of precision, of the numbers of kangaroo rats actually eliminated by predation. Few records were obtained for the part of year when rats were apparently most important in the food of the rattlesnake; also the

striking and killing of a certain proportion which escape being eaten may be an important ecologic factor. Insofar as determined, the numbers eliminated by predation are far short of the reproductive potential. That predation is not a decisive factor in the population trends of these rodents is indicated by their drastic fluctuations over periods of years while predator populations remained fairly stable. However, at times when the kangaroo rat population has been much reduced by unfavorable weather, predators may be instrumental in holding it to a low level over periods of years. The predators would not be starved out readily by the lack of kangaroo rats as alternative prey species are available. Snakes in particular would probably take a higher proportion of the kangaroo rat population when its level was low. They would not, at such times, turn their attention to more readily available foods since they do not select their prey in active hunting, but usually lie in wait and take whatever comes to them.

Weather and disease.—Evidence of disease was not often noticed in the kangaroo rats handled. The most common ectoparasites were small orange mites that occurred in clusters about the genital and anal regions or, less frequently, on the ears of a large proportion of those examined. Fleas were rarely noticed on those trapped in 1939, 1940, and 1941, but in 1946 nearly all of those trapped were infested. On June 21, 1938, an adult female found dead, apparently from disease, had an unusually heavy infestation of mites. Three of eight taken in a short trap line, September 5, 1938, appeared diseased; they were slow and listless in their movements, had lost the hair from their tails, and their eyelids were swollen and partly shut with mucous discharges. Small intestinal nematodes were often voided by those handled.

A few kangaroo rats were found dead on the surface near their burrows in cold and wet winter weather. One such specimen had a pneumonic condition. At the commencement of field work in March, 1938, after several weeks of unusually heavy spring rains, numbers of dead kangaroo rats were noticed. In this connection, a statement by Dale (1939: 709) concerning *D. h. saxatilis* of the same foothill belt near the north end of the Sacramento Valley is of interest: "This factor of excessive moisture may be an important one in restricting the spread of *Dipodomys*. It is undoubtedly the principal cause of decimation over large areas in severe winters such as that of 1937–38, and it has been observed repeatedly that places with adequate drainage are preferred in the optimum habitat. It is true, nevertheless, that *D. h. saxatilis* is surprisingly tolerant of moist conditions. Even in the well-drained slopes, where these animals are quite successful, the soil is wet to the underlying hardpan for practically the entire rainy season. It is not unusual to find that burrows have been cleaned out after heavy rains and to note that the excluded material has been thrown out in the form of mud." That the kangaroo rats are sensitive to wetting and chilling was shown by experience in live-trapping them. Nesting material of finely shredded cloth or burlap was provided in the traps set in cold weather, but the animals often became wet from rain leaking through the traps, from their urine, or from moisture condensed from their respiration. Those chilled from wetting were slow in movements and unsteady in gait when released. They ultimately were apt to be found dead in the traps if caught on several successive

nights. In routine trapping, the same trap line was not run on consecutive nights for this reason.

In their shallow, poorly constructed burrows, the animals are susceptible to wetting and chilling at times when winter or early spring rains are sufficiently heavy and prolonged to saturate the soil. Extremes of such unfavorable weather conditions occurring periodically at several year intervals may be the most important controlling factor in the distribution and local abundance of the species.

Movements.—In general, kangaroo rats of this species are loath to leave the vicinity of their individual burrows, but stay sufficiently near to reach shelter in a sudden dash when danger threatens. Their normal range of activity is small. Individuals recaptured frequently over periods of months were most often trapped each time within the same small area less than an acre in extent. For 1270 individuals, each recaptured one or more times, recorded movements were as follows: 36.6 per cent, less than 50 feet; 17.9 per cent, 50 to 100 feet; 11.4 per cent, 100 to 150 feet; 8.7 per cent, 150 to 200 feet; 6.7 per cent, 200 to 250 feet; 11.3 per cent, 250 to 500 feet; 8.0 per cent, more than 500 feet. Many of these were recaptured only once, most often near their home burrows, so the extent of their movements is not shown. Only ninety-nine of those marked had records extending for a year or more. Most of these were recaptured many times at different places over periods of months and the general extent of their movements is better shown. Twelve had made recorded movements of less than 100 feet, sixty-three had moved from 100 to 400 feet, and twenty-four had moved more than 500 feet. Most of the group that moved more than 500 feet had made definite shifts and had settled down in new foraging areas. Probably most of the foraging range of an individual is in a familiar area 100 to 400 feet across. Animals released from live traps usually evidenced familiarity with their surroundings. If alarmed, they would dash unerringly for the shelter of a burrow over an apparently familiar route, sometimes a well-beaten trail, sometimes a scarcely discernible runway. The home burrow was often attained by a series of zigzag dashes along trails, pausing and stopping at or momentarily entering holes along the way. A released kangaroo rat has been observed to run as much as 500 feet in this manner, but dashes of 20 to 50 feet were most frequent.

Shifts in range were irregular and unpredictable both in distance and in time of occurrence. Such shifts involved both adults and young. Apparently young are not apt to shift to new areas at the time they become able to forage independently. On one occasion, during the course of bait testing, an adult (female ?) and a well grown young were gathering grain together and returning with it to the same burrow entrance. Young marked at an unusually small size, 20 to 30 grams, and whose subsequent histories were known, usually did not shift for periods of weeks; in many instances they stayed in the same location, where they grew to adult size. Others were known to have made shifts when they were about two-thirds grown (weight 40 to 50 grams); shifts evidently are more likely to occur in animals of this size than in younger or older ones.

In the process of foraging, kangaroo rats do not cover uniformly the small

area within which their activities are mostly limited, but tend to keep on their own regular runways and gather food along the edges or where runways lead into thick vegetation.

Though kangaroo rats are inclined to be hostile toward members of their own species, lack of true territoriality, comparable to that of some birds for instance, is indicated by the fact that burrow systems of different individuals are connected by surface runways. In the quarter-acre enclosure, where eight males were kept, all the burrow entrances were linked by a network of interconnecting trails, indicating a good deal of "visiting" and perhaps communal use of some of the burrows. Individuals spending so much of their time underground could not be expected to maintain exclusive rights to surface areas. It is evident that each one uses many different burrow systems. In the course of foraging expeditions some distance from the home base, familiar outlying burrows are probably relied upon as emergency shelters. Of the 118 burrows excavated in January, 1940, all showed evidence of use by kangaroo rats within, at most, a few days though only five were actually occupied.

In most mammal species, males are more inclined to wander than are females. That this is not the case in the kangaroo rat was indicated by the marked ones recaptured, 652 males and 618 females. Sixty of these (nineteen males and forty-one females) were found to have covered distances greater than 900 feet between captures. Of five recorded at distances greater than 2500 feet, all were females, and twelve of the fifteen that moved more than 1600 feet were females. Most of those recaptured, 85.0 per cent of the males and 83.4 per cent of the females, had made movements less than 300 feet. Comparatively few, 12.1 per cent of the males and 9.2 per cent of the females, had moved distances of 300 to 900 feet.

It is not clear to what extent individual shifts of range are effective in the population turnover of an extensive area. In the vicinity of the Experimental Range headquarters and an adjoining pasture, where annual poisoning of ground squirrels eliminated most of the kangaroo rats also, the population remained low through the entire year.

Roads, and perhaps cattle trails, provide travel ways along which the rats are apt to make unusually long movements. Many of the longer movements on the trapping area had evidently been made by way of the road which ran diagonally through the length of it.

SUMMARY

The Tulare kangaroo rat, with its several geographic representatives, is a rodent characteristic of the lowland grazing areas in California, particularly the more arid parts of the Sacramento–San Joaquin Valley system and the foothill belt encircling it. Throughout much of this region the kangaroo rat is abundant and competes to varying degrees with grazing livestock for the sparse annual vegetation. In general it is restricted to areas of poor soil, but it has a fairly wide range of tolerance to varying habitat conditions. Its burrows are short and of simple construction compared with those of other kangaroo rats, but they

vary greatly according to soil type. In fine, deep soil, the burrows may have a two or three story arrangement with several entrances and thirty or more feet of tunnel. In shallow or coarse soil the burrows are simple. Even in rocky areas, where hardly any digging is possible, the kangaroo rats may be abundant and find sufficient shelter beneath residual boulders. Besides its home burrow, it may use and keep in repair a number of outlying burrows which serve as emergency shelters when the animal is foraging. Of 118 burrows showing evidence of recent use, only five were found to be occupied when excavated. The animals may at times rest on the loose soil of the burrow floor. In the breeding season, or in cold winter weather, they may make loose straw nests. The shallow and simple burrows render the animals vulnerable to extremes of weather. During periods of prolonged and heavy rains they may be drowned out or become chilled and susceptible to pneumonia or other disease. The available evidence indicates that such extremes of unfavorable weather conditions are the factors which ultimately limit the population.

The storing habit is less developed in this species than in other members of the genus; its habitat provides a year-round food supply. During the winter and early spring months, green leaf material, principally of filaree, provides most of the food. In the dry season, seeds of grasses, particularly annual bromes and fescues, make up most of the food, but seeds of filaree, turkey mullein, and several legumes are also used extensively. Soft chess was by far the most important food plant in the locality of this study. Storing of food is usually on a small scale and serves principally to make available a constant food supply during the greater part of the 24-hour day that the animal spends underground. Its small stomach capacity is doubtless correlated with this storing habit and ability to carry food in the cheek pouches.

The forage lost through kangaroo rats much exceeds the quantity actually eaten by them. In an enclosure stocked at the rate of thirty-two kangaroo rats per acre, the decreased yield was such that a destruction of 11.6 pounds (dry weight) for each animal was indicated during the seven months growing season, with some further loss during the dry season. The kangaroo rats' habit of cutting stalks to clear away impeding vegetation is evidently an important factor. It is also probable that quantities were carried underground. Stunting of the vegetation, by their grazing, during the early stages of growth prevented the potential yield from being fully realized.

Widely fluctuating changes in population level from year to year are characteristic of this species; rapid population turnover and sensitivity to certain environmental factors are involved. At the San Joaquin Experimental Range, near the upper altitudinal limit of distribution and in an area of heavier rainfall and more abundant forage than characterizes the range as a whole, population gains were coincident with abnormally dry years, and drastic reductions apparently coincided with unusually heavy and prolonged rainfall. Actual drowning out of the rats, or chilling in the saturated soil of their shallow burrows, may effect decimation of the population in critically wet periods.

Many natural enemies were present in the locality where kangaroo rats were

studied; the rattlesnake, horned owl, coyote, gray fox, barn owl, gopher snake, and red-tailed hawk, in perhaps that order of importance, all took substantial numbers. Predation may be a factor in delaying recovery in numbers at times when the population is low.

Live trap census for three different years on an eighty-acre area, based on the ratio of recaptured animals from a previous sampling period to others, indicated winter and early spring populations of about four per acre with gradual increase through the early summer and fall to seven per acre in 1939 and only five per acre in 1941. But by the spring of 1946, the population had decreased to only one per acre. In 1935, before trapping was begun, high road counts and numbers found dead on poisoned plots indicated a population of perhaps thirty per acre.

Road counts at night provide a useful method of comparing the population densities of areas when allowance is made for the facts that distribution is uneven, with concentrations on better drained ground and on dusty open places, and that most of the time is spent underground, even at night. The peak of activity is soon after dark. This is somewhat reduced by moonlight, wind, or rain. With a censused population of between four and five per acre, an average of 2.3 per mile was counted. Sampling was done during nights and hours apparently favorable for activity.

The kangaroo rat has a high reproductive potential. Litter size varies from two to five and may average about three. Adult females may produce as many as three litters during the breeding season, which extends over most of the year. In November, December, and January, however, only small percentages are breeding. The peak of the breeding season is in April. Most of the females examined then were either in oestrus, gravid, or lactating. Young born early in the season may mature in time to produce two successive litters of their own before winter. It is estimated that a single female might have as many as thirty progeny by the end of the breeding season.

The hundreds of kangaroo rats recaptured one or more times had mostly made movements of less than 100 feet, and it appears that most activity is within this small radius. However, some of those recaptured had shifted to new locations several hundred feet (in one case .6 mile) from the original site of capture.

As compared with the ground squirrel and pocket gopher, this kangaroo rat is a species of very minor economic importance. Its relatively small size and habitat limitation to arid situations with meager forage render competition with livestock light under ordinary conditions. In the course of population fluctuations, a characteristic of the species, it may occasionally attain spectacularly high concentrations capable of destroying a large share of the sparse annual forage crop. On limited areas, at certain times, it may thus compete severely with cattle or sheep. Local control may occasionally be justified and can be accomplished easily. In March and April, natural foods, such as ripening seeds, are preferred to grain baits and control would be relatively ineffective at that season. In the absence of artificial control, high populations are apt to be reduced by natural mechanisms.

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SHREW-MOUSE PREDATION DURING LOW MOUSE ABUNDANCE

BY W. ROBERT EADIE

Evidence of predation by the short-tailed shrew (*Blarina brevicauda*) on the field mouse (*Microtus pennsylvanicus*) during a winter of relatively high mouse abundance (1942–43) has previously been reported (Eadie, 1944). Data from the analysis of 200 scats collected at that time from the vicinity of winter nests in open field habitats at Ithaca, New York, showed that significant mouse remains occurred in 56 per cent. Data on shrew predation at other stages of the mouse cycle should be of value in defining the relationship between these animals. A method of collecting scats on a monthly basis was devised and placed in operation in the area of the previous study during the winter of 1943–44 when the field mouse population was at a relatively low level locally.

Methods.—Observation of the fact that *Blarina* frequently deposits a dropping on the wooden base of a visited but unsprung snap-trap led to the formulation of a method for the collection of dated fecal samples. Four-inch paper squares were placed at 10-foot intervals in rows across the study area and a pinch of oat flakes deposited on each. These papers were placed in small mammal runways where possible, but otherwise in any likely spot such as at the bases of grass tufts. If pressed close to the ground surface, they usually remained in position except when relatively high winds were blowing. On the first trial of this method, 33 per cent of the paper squares were visited by short-tailed shrews which left one or two droppings on each over a 24-hour period. Field mice deposited droppings on 75 per cent of the stations during the same period. It is apparent that this technique might readily be developed to obtain relative census figures on certain small mammals under uniform conditions with a minimum of disturbance to the animals and habitats. In utilizing this method for the collection of fecal samples throughout the winter, obvious difficulties were encountered because of unfavorable weather conditions. Nevertheless, even

with a ground cover of snow, the method was used successfully by placing the collecting papers along sub-nivean runways.

Results.—During the winter of 1943–44 a total of 255 scats from *Blarina* were collected and analyzed in the laboratory by monthly periods from November through March. During this period the field mouse population was estimated by trap removal methods in similar habitats as ranging from a relative fall figure of approximately forty mice per acre to a late winter low of ten per acre. On a relative basis, the initial fall mouse population was only half as dense as in the previous year studied although the late winter levels were about the same. During the same period the *Blarina* population was estimated as ranging from approximately three to one per acre from fall to late winter, a relative density corresponding to that of the previous year studied. The results of the scat analysis are shown in Table 1.

TABLE 1.—*Frequency percentage of food types in 255 winter scats of the short-tailed shrew by monthly periods and for total period, 1943–44*

	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	TOTAL PERIOD
Number of Scats	45	68	68	40	34	255
Insects (all types)	89	46	69	83	79	69
Millepedes and centipedes	64	49	47	28	27	45
Crustaceans	13	12	37	40	24	25
Annelids	53	10	24	18	3	22
Mammals (all types)	18	13	19	13	35	18
Mice	13	3	19	8	35	14
Shrews	2	10	0	3	0	4
Unidentified	2	0	0	3	0	1
Plant materials	16	9	9	3	17	10
Molluscs	0	10	3	3	3	4

Because of the small number of scats involved on a monthly basis, the fluctuations in the occurrence of mouse remains have a limited significance. However, the low frequency of mouse remains in December scats is compensated by a comparatively high shrew occurrence. This may possibly be explained by the fact that a colony of *Sorex cinereus* was present in the area of collections for December, and seemed to be replacing mice in the diet of *Blarina*. Shrew remains were recorded as food only when bone fragments or pieces of skin with hair attached occurred in the scat along with other masses of shrew hair. Evidence of *Blarina* predation on long-tailed shrews has been very limited. Hamilton (1940) recorded the occurrence of the remains of *Sorex fumeus* in one *Blarina* stomach and suggested the possible importance of the short-tailed shrew as a predator on *Sorex*. Shrew remains occurred in the scats of three of the five winter months covered by this study. In the previous year studied (Eadie, 1944), shrew remains had a frequency percentage of two in a total of two hundred winter scats of the short-tailed shrew.

The figure for March may indicate that mice are more vulnerable to shrew

predation in the early spring when cover may be at a minimum, but the number of scats involved is too small to permit a definite conclusion on this point.

For the total winter period covered by the study, mouse remains had a frequency percentage of 14 in the total of 255 scats as compared with a frequency percentage of 56 in the previous year studied.

The possibility that some of the mouse remains in the scats represent carrion still exists although light was shed on this problem by some indirect observations on the study area for March. In this area thirty-four scats from *Sorex cinereus* were collected from the paper squares. When analyzed in the laboratory, these revealed only the remains of adult insects, insect larvae and pupae, millipedes, centipedes, and earthworms. In the *Blarina* droppings from this area during the same period, mouse remains had a frequency percentage of 35 and it seems reasonable to assume that if a large proportion of this represented carrion such mouse remains would appear in the *Sorex* scats also. Since this was not the case, it seems to be a strong indication that the major portion of the mouse remains in the *Blarina* droppings represents actual predation in this instance, at least.

Conclusions.—These data show that mice formed a significant portion of the diet of short-tailed shrews in open field habitats during a winter of low mouse abundance as well as in a "peak" year of abundance as previously recorded. The apparent higher rate of predation by the shrews in a year of greater mouse abundance seems to be one more indication of the increased vulnerability to predation experienced by relatively high population densities of the prey species.

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SEASONAL TRENDS IN BURROWING OF POCKET GOPHERS (*THOMOMYS*)

By Milton A. Miller

Various aspects of burrowing by pocket gophers have been reported. Some of these are: effects on soil formation, erosion, and ecologic succession (Grinnell, 1923 and 1926; Larrison, 1942; Ellison, 1946); relation to land use (Buechner, 1942); relation to type of soil (Davis, *et al*, 1938); rate of digging (Mohr and Mohr, 1936; and Hill, 1944); and burrowing in snow (Marshall, 1941). Several descriptions of the burrowing process and of burrow systems have been published (Breckenridge, 1929; Criddle, 1930; Storer, 1942; to mention a few). Occasional mention of seasonal periodicity in burrowing is encountered in the literature (Miller, 1946), but, in general, this phase of gopher activity has not been thoroughly investigated. The present study was undertaken to determine seasonal trends in burrowing activity of pocket gophers (*Thomomys bottae navus*), especially in relation to soil moisture and soil temperature.

Knowledge of burrowing trends has practical application, since gophers are best controlled when they are most active. Evidence of recent work, such as fresh excavation mounds and earth plugs, greatly facilitates the location of inhabited runways for placing traps or poisoned baits. When fresh "sign" is lacking, however, efficiency of control decreases. Burrow systems indicated only by old mounds are frequently abandoned or so extensively plugged that an excessive amount of time and labor is required to find an active runway.

Procedure.—The site selected for study was a plot of nearly one-half acre (200 x 100 feet) in a fallow field on the University of California Farm at Davis, California. The surface of the ground was fairly smooth, covered with the prevailing weeds, and showed moderate gopher infestation. The plot and surrounding areas were not cultivated, irrigated, or otherwise disturbed during the period of observation. The soil was Yolo sandy loam. Observations were made every week for a year (April 1944 to April 1945) to study the following points: (1) the number and distribution of new gopher workings, (2) soil moisture content, and (3) soil temperatures. Data on rainfall and air temperatures were available from the University.

The weekly census of gopher work was taken by marking each new excavation mound or earth plug within the boundaries of the plot with a small numbered stake (Pl. I). Excavation mounds are somewhat fan- or crescent-shaped piles of earth, varying considerably in size, which the gopher has loosened in digging and pushed to the surface, a little at a time, through the open ends of tunnels. The last few loads of dirt are used to close the opening of the tunnel. Earth plugs are roughly cylindrical cores of earth with which the gopher plugs short passageways that lead from horizontal and usually shallow runways to the surface. These temporary tunnels are presumably used by the gopher in emerging to forage on the surface of the ground and in returning to the burrow. Separate counts were made of the two types of work, excavation mounds and earth plugs. Prior to the

first tally, all old workings were either obliterated or identified with unnumbered stakes. To gain information on the distribution and pattern of the gopher work, the position of each new mound or earth plug was plotted when tallied.

For soil moisture determinations, weekly earth samples were taken with a soil sampling tube from each of the four corners of the plot at four depths; 0–6 in., 6–12 in., 12–18 in., and 18–24 in. These were weighed before and after oven-drying and the moisture content of each was determined as percentage of dry

PLATE I

Pattern of a pocket gopher burrow system as indicated by distribution of excavation mounds and earth plugs (both types of work marked by white stakes) produced in an eleven-month period (April 17, 1944 to March 18, 1945). A small part of this system is not shown, and the two types of work are indistinguishable in the photo.

weight. The values of the four samples for each depth did not vary significantly and consequently were averaged. Also, to simplify the analysis still further, the averages for different depths were sometimes averaged, for example, the 0–6 in. and 6–12 in. averages were combined to give a soil moisture value for 0–1 ft. Soil temperatures were taken at a depth of one foot (about median for burrows) with a recording thermometer.

Acknowledgments.—The author is greatly indebted to Miss Virginia Dohrmann for valuable assistance in this project. Acknowledgment is also due to Prof. Tracy I. Storer, University of California, Davis, for helpful advice and criticism, and to Professors F. J. Veihmeyer, B. D. Moses, and L. E. Davis for use of equipment and facilities.

Results and Discussion.—Although no actual count of the gophers in the area was possible, their number could be roughly estimated from the distribution of burrow systems, since they are remarkably solitary. It is estimated that all or a considerable part of about twelve burrow systems were included within the plot at the start of the study and that possibly two more were added during the year.

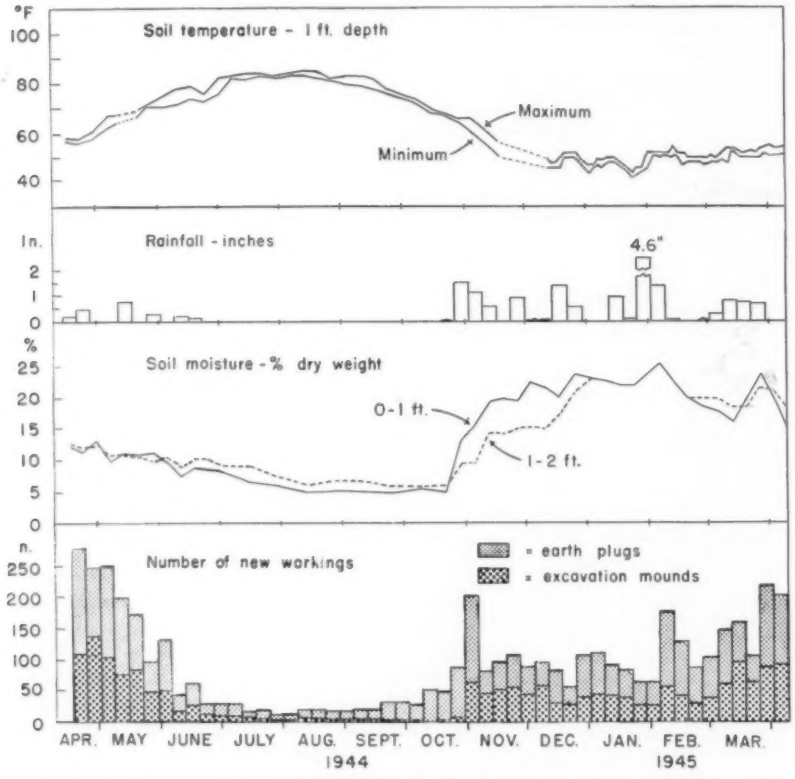

FIG. 1. Seasonal trends in burrowing of pocket gophers in relation to soil temperature, rainfall, and soil moisture. In the temperature record, dashed lines indicate periods when the thermometer was out of order.

The records indicate fluctuations during the year in the population of gophers, but losses from predators (an owl was known to roost in a palm tree about 300 yards away and on one occasion a gopher snake was discovered in the plot), death, and emigration were probably balanced in the main by gains from birth and immigration so that a dynamic equilibrium was maintained. One system of the original twelve was inactive for seven months (July to February) and then became active again. Five systems were quiescent for about a month, and almost all

showed occasional shorter lapses in activity. Renewed burrowing in a system that had been inactive for a relatively long time (one month or more) might be attributed to a new occupant moving into the vacancy left by the death or desertion of the previous tenant. Evidently, nearly all the burrow systems were inhabited throughout most of the year, either by the same or different gophers. Furthermore, practically all showed some signs of burrowing during the year, but with seasonal differences in intensity.

Seasonal trends in the rate of burrowing and a general correlation between burrowing activity and seasonal soil conditions are graphically shown in Figure 1. The amount of digging attains a peak in spring, with an average of 86 new mounds and 109 new earth plugs per week per 20,000 square feet, or about 187 mounds and 237 earth plugs per week per acre. The burrowing rate tapers off gradually to a low level through the summer and early fall when the soil is hot and dry, rises suddenly following the first autumnal rains, and maintains a moderate level for the duration of the fall and winter when the soil is wet and cool. The trends in production of earth plugs and of excavation mounds ran more or less parallel except in the early fall, a month or two before the first rain, when the number of new earth plugs per week increased gradually and significantly (from an average of eleven through August to over sixty in the last two weeks of October) while production of new mounds was practically nil. The fall acceleration in earth plug formation suggests a significant increase in surface foraging by the gophers at this time. This may be associated with several factors, cooler temperatures, depletion of underground food stores, and/or breeding activities. It is not related to soil moisture content which was practically constant (between 7 and 8 per cent) during this period.

Burrowing activity, especially the rate of mound formation, seems to be a function of the amount of moisture in the soil (Fig. 2). For Yolo sandy loam, the optimal range of soil moisture for excavating lies approximately between 9 and 18 per cent. When the water content of the soil drops below 9 per cent, relatively few mounds are produced. When the soil contains more than 18 per cent water, the burrowing rate again drops off, but not as much as when the soil is dry. This decrease may be attributed to the fact that wet soil tends to stick and form large lumpy aggregates, and hence is not easy to handle. Presumably, burrowing is most intense when the soil is tractable—not too wet or too dry. Such conditions prevail in the spring.

Since the rate of burrowing may also be associated with soil temperature the question arises, which is the more important factor, soil moisture or temperature? Under conditions of this study, the effects of these two factors on burrowing are difficult to separate since trends in soil moisture and soil temperature are so closely correlated. The inference from human experience is that soil moisture would be more important because it is difficult to dig in hard dry soil as well as in very wet soil. The sudden increase in gopher mounds immediately following the first autumnal rain (Fig. 1) and the fact that pocket gophers burrow actively in irrigated fields during summer, in contrast to their negligible work in dry fields, also support the assumption that soil moisture rather than temperature is the domi-

nant factor. Other factors, such as seasonal needs for construction of nests, storage chambers, and breeding activities undoubtedly have some influence on burrowing of pocket gophers. These may account for the occasional discrepancies and minor fluctuations in the general burrowing trend, which is primarily conditioned by soil moisture.

It should not be inferred that the burrowing of gophers (or the behavior of mammals in general) is rigorously determined by a single physical factor, or even

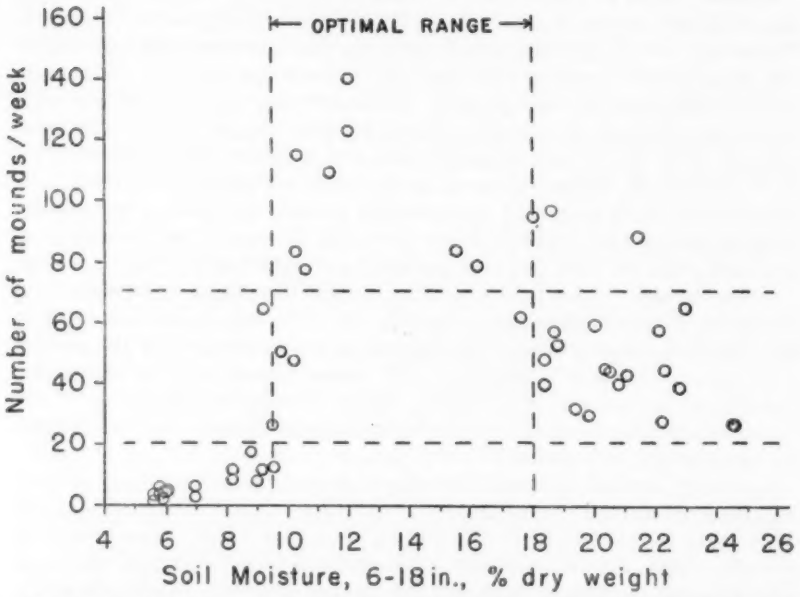

FIG. 2. Association between soil moisture and rate of burrowing by pocket gophers (in Yolo sandy loam). The ordinate expresses the number of new excavation mounds per week on a fallow plot of nearly half an acre (200 x 100 ft.). Three main groups of data points (blocked off by dashed lines) show: (1) that the optimal range of soil moisture for burrowing lies between 9½ and 18 per cent, (2) that gophers do little excavating when the soil is dry, and (3) the rate of burrowing decreases when the soil contains more than 18 per cent water.

a combination of factors, like the forced tropisms of lower organisms. Some intelligence on the part of the gopher, or at least associative memory as to what conditions are best for burrowing, is undoubtedly superimposed on an instinct for digging.

The practical applications of this study are self-evident to anyone with experience in gopher control. As previously stated, gophers are most easily eradicated when there are plenty of fresh mounds to reveal the location of inhabited burrow systems. Fortunately, the moist, tractable soil, which favors burrowing, is also easiest to probe for runways. An especially favorable time for gopher control in

the Sacramento Valley and climatically similar regions is immediately after the first heavy rains of autumn. At this time, fresh gopher mounds are abundant, the vegetation is low so that mounds can easily be seen, probing for tunnels in active use is easy, poison baits are readily accepted, placement of traps is not difficult, and this is a slack period for agricultural labor in the area. Moreover, control at this time is efficient because it precedes the winter and spring breeding season. Summer and early fall, conversely, are obviously poor times for gopher control on unirrigated lands. Fresh gopher work then is scarce, it may be obscured by vegetation, and probing and digging are difficult.

Summary and Conclusions.—Weekly records of new pocket gopher work, of soil temperature, and of soil moisture were taken for a year from a half-acre plot in an uncultivated fallow field at Davis, California, to determine seasonal trends in burrowing in relation to soil conditions.

There was a general association between burrowing trends and seasonal soil conditions. The rate of digging was highest in spring, tapered off gradually to a low level through summer and early fall when the soil was hot and dry, rose suddenly following the first autumnal rains, and then maintained a moderate level for the duration of the fall and winter when the soil was moist and cool.

Soil moisture is considered to be the dominant factor controlling the rate of burrowing by gophers. For the type of soil, Yolo sandy loam, the optimal range of soil moisture for excavating is roughly between 9 and 18 per cent dry weight. Little burrowing occurs when the soil is dry, and only a moderate amount in very wet soil. Presumably, burrowing is most intense when the soil is tractable—not too wet or too dry.

An acceleration in the rate of earth plug formation noted during early fall suggests a significant increase at this time of year in surface foraging by the gophers. This may be attributed to cooler soil temperatures, depletion of underground food stores, and/or mating activity.

For reasons given, gopher control is most efficient when fresh mounds are abundant. An especially favorable time for eradication of gophers in the Sacramento Valley and climatically similar regions is shortly after the first heavy rains of autumn.

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A MIDSUMMER STUDY OF THE SOUTHERN FLYING SQUIRREL

BY JAMES S. JORDAN

The literature on the southern flying squirrel (*Glaucomys volans*) contains little information on sex ratios and population numbers. To my knowledge, the only published data of this sort are those of Burt (1940:48) who live-trapped forty-five flying squirrels on the Edwin S. George Reserve, near Pinckney, Michigan. The sex ratio in these squirrels was 3:2, or twenty-seven males to eighteen females. Burt did not believe this to be a representative ratio. Six of these squirrels were trapped in a plot of woods of 3.72 acres, a density of one squirrel in .62 acres

In July and August, 1946, the writer undertook a study of the flying squirrel in a twenty-eight-acre oak-hickory woodlot in the vicinity of Ann Arbor, Michigan. The purpose of the investigation was to obtain information on sex and age class ratios, population numbers, cruising radius, and habitat preference. A twelve-acre woodlot bordered the study area on the east, but was left untrapped primarily because of the small diameters of the stems and the almost complete lack of underbrush and tree reproduction. Other than this adjoining woods, the area was separated by open fields from any other woodlot. It was believed that the separation was great enough to preclude free interchange of flying squirrels between neighboring woodlots and the one under study.

Trapping, Handling, and Marking.—The area was live-trapped in four sections, arranged arbitrarily for convenience in moving traps which numbered between twenty-six and forty-five. Each section was trapped until results indicated that no new squirrels would be taken. It was expected that an interchange of squirrels would take place between sections, but, as will be indicated later, a notable exception to an interchange occurred. All traps were baited with sunflower seeds. Shelled corn was used on occasion, but was neglected by the squirrels if sunflower seeds were also present in the traps. For the first three nights of the study, traps were placed in rows two chains apart with about one chain between traps, but this system was modified to one wherein the traps were located adjacent to large trees and in otherwise more attractive spots.

This permitted greater freedom in choosing trap locations, and they were never more than three chains apart in any direction. Such a concentration of traps would not be necessary in a study covering a longer period of time, but the present investigation extended over only two months and it was therefore advisable to retrap individuals at intervals of one or two nights. Of all traps which were successful in making captures, only six were located above ground level, a fact that conflicted with the previously accepted techniques of attaching them to the boles of trees.

For handling the captured squirrels, a cone of 1½ inch mesh hardware cloth was constructed with the open end 3¼ inches in diameter. The squirrels readily entered the cone from the trap and were securely held at the small end after a handkerchief was stuffed in behind them. A foot was then led through the mesh and a distal phalanx was clipped according to a simple formula which required the clipping of no more than one phalanx from either front or hind toes. The use of the cone left both hands free for the marking operation. Following the marking, the squirrels were maneuvered into a bag and then picked out with the hand. Data on size, sex, breeding condition, pelage color, apparent health, and ectoparasites were recorded at this time.

Sex and Age Class Ratios.—A total of thirty-two flying squirrels were captured during twenty-three nights of trapping. Ten individuals were captured once; the remaining twenty-two were trapped a total of seventy-three times. The sex ratio in the thirty-two squirrels was 88:100, or fifteen males to seventeen females. Two age classes were recognized: adults and juveniles. Some difficulty was encountered in placing the individuals in their proper class, but the task was satisfactorily accomplished after employing a method similar to that used by Allen (1943:123–125) on fox squirrels. In midsummer, adult male flying squirrels are of large size and possess a scrotum which is either obvious upon visual examination or one which is thinly covered with fur and either slightly or heavily pigmented with black. Juvenile males are comparatively small and possess either a small scrotum densely covered with fur or one which cannot be found after manual examination. Adult females are of large size or possess long, rough teats which indicate that they have bred at least once. Juvenile females are comparatively small and possess minute teats or teats which lack the long, rough appearance of the adult female. Flying squirrels produce two litters per year (Howell, 1918:8). But it is not known whether females from the late summer litters breed during their first spring. If they do not, then the teats of such females would retain their juvenile characters into midsummer. In order to prevent the possibility of classifying these females as juveniles, on the basis of the condition of the teats, one may properly use the factor of comparative size. The ratio in age classes was 68:100 (thirteen juveniles to nineteen adults). The sex ratio in juveniles was 86:100 (six males to seven females). In adults, the sex ratio was 90:100 (nine males to ten females). The high differential in favor of adults, and the corresponding scarcity of spring-born animals, may be explained by the fact that the investigation was completed before the late summer litters appeared. This disproportion in age classes

suggests one of two things: (1) most spring-born young had been removed, since the average litter size is four in this species (Howell, *loc. cit.:* 8), or, (2) females from the late summer litters do not breed during their first spring.

Habitat.—Some idea of the type of habitat preferred by flying squirrels may be gained by drawing on the records of the tree species, their sizes, and relative dominance throughout the study area. Records of this sort were made for a total of 131 trees immediately adjacent to trap sets. The d.b.h. (diameter breast high) is used to indicate dominance because a conscious effort was made to place traps adjacent to large trees. The average d.b.h. of 131 trap trees was 13 inches. Dominance was expressed in the following order: oaks (red, white, and black), hickories (shagbark, bitternut, and small-fruited), white ash, American elm, black walnut, red maple, and hop-hornbeam. Also present, but in small numbers, were basswood, bur oak, black cherry, and aspen.

The density of underbrush is also an important factor in evaluating flying squirrel habitat. Of a total of 131 trap locations, fifty nine were successful in making captures. The density of underbrush surrounding each of the fifty-nine locations, up to a radius of 30 feet, was given one of four values: heavy, medium, light, or zero. The classification was a relative one; stems were not counted, nor were percentages calculated for the amount of ground area visible at each location. It was necessary only to glance at the area and assign to it a rough value. Nine locations were surrounded by heavy density of underbrush, twenty-one by medium density, thirteen by light density, and sixteen by zero density. However, if the underbrush was absent over a large area it directly affected trapping success. The west end of the woods contained an area of about five acres where the underbrush was almost completely lacking. Grass was the predominant ground cover, a condition brought about through heavy overgrazing by domestic stock. Only two squirrels were captured in this area during five nights of trapping. The capture of white-footed mice (*Peromyscus leucopus noveboracensis*) was also much reduced. The exact number of mice was not recorded, but the writer vividly recalls that very few traps were disturbed in this overgrazed area. The implication here is that a continuous lack of underbrush in an area as small as five acres will discourage its use by both white-footed mice and flying squirrels. In the case of the mice, this merely confirms the findings of other investigators. The limitations which it places upon the flying squirrels are less easily explained. Trapping results show that they often come to the ground in search of food and that they venture into a ground cover of grass alone, provided that heavier cover is close at hand. Thus, it is apparent that flying squirrels and white-footed mice are governed by the same requirements of ground cover. Flying squirrels do not require surface water in midsummer. The woodlot is drained by small streams, but all remained dry during the period of investigation.

Movements.—Flying squirrels have a limited cruising radius. The greatest distance between any two captures of the same squirrel throughout the entire woodlot was approximately 175 yards. The usual range was between 60 and 160 yards, most of them covering the latter distance. In shape, the woodlot

resembled the letter L. Its vertical portion contained close to eight acres and was trapped separately, yielding a total of eleven squirrels. Each squirrel was captured at least twice during six nights of trapping. On the basis of captures, none of these squirrels visited the remainder of the woods, but all stayed within the eight-acre section throughout the investigation. Only one squirrel invaded the eight-acre section, and its den was located less than 100 feet outside.

Released squirrels exhibit a variety of reactions. If placed on a small sapling they appeared undecided about using it as a means of escape, some preferred to jump to the ground rather than attempt a glide from such a low height. They are not as adept nor can they approach the speed of the other tree squirrels on the ground. After reaching a rough-barked tree they move rapidly. They climb to the top and take off for another tree in a smooth, descending arc and strike the second tree on the lower part of the bole. When liberated on the ground, some squirrels did not attempt to escape, but began to dig and feed in leaf litter, apparently oblivious of the writer who stood a few feet away. One individual climbed a red maple tree and fed upon a fungus growth for twenty minutes.

When gliding, the petagia are spread farther apart between the front legs than between the hind ones. The squirrels make right angle turns and avoid obstacles while in mid-glide. In glides witnessed at close range, there appeared to be a fluttering, up and down, motion of the tail. The length of glide depends on the height at which it is begun. The longest glide witnessed was about 50 yards, but was made across a slope. Most glides were less than 100 feet, and in all glides the squirrels chose to strike the boles of large, rough-barked trees.

Two snags of small diameter were climbed to investigate den sites into which squirrels had disappeared. Squirrels were aroused from these sites at later dates, but there were also days when no squirrels appeared. These animals were found to utilize several refuge dens and the above observation suggests the possibility that they have more than one home den. No released squirrels were seen to glide over into the bordering, untrapped woodlot.

Health.—Nearly all of the squirrels carried fleas and all except one appeared to be in good health. The exception was one afflicted with several pea-size growths about its head and body. Similar growths are commonly found on cottontails. The causitive agent is believed to be transmitted by fleas (Hickie, 1940:57–58). The flying squirrel is not a hardy animal. Three individuals died from exposure while in the traps during cool summer nights even though cotton batting and adequate food was provided.

Associated Species.—Other animals captured included approximately one hundred eighty white-footed mice, four shrews (*Blarina*), and one red squirrel. Direct observation and signs indicated the presence of the red fox, fox squirrel, raccoon, striped skunk, woodchuck, and cottontail.

Summary.—During July and August, a total of thirty-two flying squirrels was live-trapped in an oak-hickory woodlot in the vicinity of Ann Arbor, Michigan. The density of flying squirrels was little more than one per acre. A total of eighty-three captures was made, only six of which were above ground level.

The sex ratio was 88:100 (fifteen males to seventeen females). Two age classes were recognized: juveniles and adults. The age class ratio was 68:100 (thirteen juveniles to nineteen adults). The sex ratio in juveniles was 86:100 (six males to seven females). In adults, the sex ratio was 90:100 (nine males to ten females). The disproportion in age classes suggests either that juvenile mortality is high or that females from the late summer litters fail to breed in their first spring.

The average diameter of 131 trap trees was 13 inches. Varying degrees in density of underbrush did not adversely affect flying squirrel activity except where underbrush was absent over an area as large as five acres. White-footed mice were similarly affected.

The cruising radius of these animals is small, usually covering about 160 yards. Eleven squirrels, on the basis of captures, remained within an eight-acre section of the woodlot throughout the investigation.

Flying squirrels in mid-glide make right angle turns and avoid obstacles. Most glides were less than 100 feet. Released squirrels exhibit a variety of reactions.

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MAMMAL NOTES FROM THE GRANDE PRAIRIE—PEACE RIVER REGION, ALBERTA

By J. Dewey Soper

In 1944, I was assigned, as part of the investigations of natural resources under the North Pacific Planning Project, the problem of distribution and abundance of birds and mammals in that portion of West-Central Alberta extending from Athabaska west to the Alberta–British Columbia boundary. Obviously, only a portion of this huge territory could be studied in a single season, therefore, it was necessary to select a more restricted area for investigations in the summer of 1944. The one decided upon was that extending from Athabaska westward to the British Columbia Boundary, embracing, west of the longitude of High Prairie, an expansive block of country which may be conveniently referred to as the Grande Prairie–Peace River Region (Fig. 1).

The present paper is concerned exclusively with the mammals recorded in the latter territory. Little was known regarding most of the larger mammals and practically nothing of the smaller ones. An interrelationship exists between the mammal data in the present paper and that in papers by Cowan (1939), Soper (1942), and Rand (1944) for more or less neighboring tracts of territory.

Work under the present project was commenced at Baptiste Lake (a few miles west of Athabaska) on May 25. June was devoted to investigations en route to and along Lesser Slave Lake, at Sturgeon Lake, and in several localities in the Grande Prairie district. In July, inquiries were carried westward, with camps at many points beyond Saskatoon Lake and Hythe, to Keeping Lake, near the Alberta–British Columbia Boundary. In the latter part of the month, a general wildlife reconnaissance was conducted southwest of Wembley to the upper Torrens River, Rocky Mountains. Data for the latter region are omitted here, but have been incorporated in a paper on the mammals of the Alberta Rockies from Torrens River south to the International Boundary. The last few days of July were spent in the Spirit River area west of Henderson Creek, on the Pouce Coupe trail. Most of the early half of August was given over to investigations north of Peace River, chiefly above Fairview, to Clear Hills and at Cardinal and Flood Lakes. Operations were then shifted to localities south of the Peace, embracing Magliore, Kimawan, and Winagami Lakes and the valley of Smoky River near Watino. With further investigations at Lesser Slave River, and points eastward, inquiries under the 1944 North Pacific Planning Project were brought to a close in early September. Winnipeg headquarters was reached on September 11.

For subspecific determinations of the small mammals, I am greatly indebted to Dr. R. M. Anderson, National Museum of Canada, Ottawa.

FAUNAL LIFE ZONE

The whole region covered by this paper is referable to the Canadian Life Zone of Merriam. Some local variations exist in the composition of both the included habitats and the indigenous fauna, but, broadly regarded, a surprising

uniformity obtains in the general faunal synthesis over vast areas of the boreal region. This unification is observed in the wide distribution of numerous characteristic species. Many, or most, of these range over hundreds of miles of territory without any appreciable alterations in coloration or structure while some others exhibit, at most, barely perceptible variations possibly of subspecific value. In the particular region under review, there is comparatively little differentiation of this kind.

A notable feature of this territory is the abrupt change in certain areas from deciduous forest to open tracts of prairie and aspen poplar parklands. Tracts of latter character are particularly evident at High Prairie, Grande Prairie,

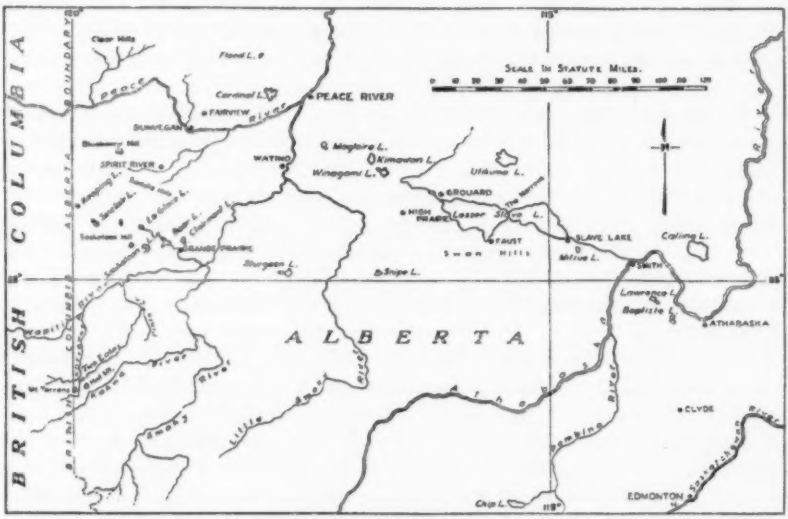

FIG. 1.—Sketch Map of West-Central Alberta from Edmonton to Grande Prairie and the Peace River Plains

Spirit River, and along the north side of the Peace from Dunvegan east to the town of Peace River. They appear superficially identical with areas in the Transition Life Zone, but in this latitude they are truly referable to the Canadian. Halliday (1937: 17) places these areas in the "Aspen Grove Section" and correctly retains them in the huge belt of country broadly referred to as the "Boreal Forest Region." A number of bird species that are normally regarded characteristic of the Transition Zone inhabit these prairies. Mammals, on the other hand, present a different situation. Not one species is more nearly typical of the Transition than of the Canadian Zone. No true campestrian mammal remotely approaches these northwestern prairie parklands. In traveling northward from Edmonton, such species as the Franklin ground squirrel, pocket gopher, badger, and little upland vole are definitely left behind either in the northern extremity of the parklands district between Edmonton and Clyde or

between the latter point and Athabaska or vicinity. All mammal species occupying the aspen grove and prairie country at, and westward from, High Prairie are derived from, or are identical with, those of the adjacent, full-fledged Canadian Zone areas. Many species which are common to the latter are either totally lacking or extremely rare in the open districts of rolling prairie, farmlands, and aspen poplar woodlands.

PHYSICAL CHARACTERISTICS

When one first sees this country he is impressed by the vast areas of existing wilderness. From a point north of Edmonton to the Arctic Ocean, it is practically unbroken. With few exceptions, the same is true of the country west and northwest of Edmonton to the Rocky Mountains. The outstanding exceptions are the now well-developed farmlands in a broad territory westward from Lesser Slave Lake. These agricultural domains are not continuous, but are divided into isolated sections of varying size. Thus, the principal blocks of farmlands may be referred to as the High Prairie, Grande Prairie, Spirit River, Peace River, and Smoky River areas, respectively.

Each of these segregated tracts is detached from the others by a broad belt of primitive woodlands composed of climax aspen poplar or dense boreal forest of the coniferous-deciduous type. All are separated from the nearest extensive agricultural lands of central Alberta by an expanse of mixedwood forest over 200 miles in width. A similar insular tract of prairie-farmlands environment, which is familiarly referred to as the "Peace River Block of B. C." (Cowan, 1939), lies in British Columbia, west of those in Alberta.

For the most part, the region dealt with here is gently to heavily rolling in character, interrupted at intervals by ridges, hills, and plateaus of varying height. The average elevation above sea level is around 2000 feet. The terrain ranges from a minimum altitude of about 700 feet in the east to over 3000 feet in the west, exclusive of the Rocky Mountains. Broadly speaking, the land dips gradually from the south and west to the Mackenzie River Basin. It lies wholly upon the Arctic watershed with chief drainage by way of the Athabaska, Peace, and Slave Rivers, whose combined waters form the MacKenzie River which flows to Beaufort Sea.

One of the greatest eminences in the region is the great "hogsback" known as Swan Hills. It lies south of Lesser Slave Lake and rises in parts to 4000 feet above sea level, or slightly over 2000 feet above the lake; it appears to extend unbrokenly in a southwestwardly direction to merge with the foothills of the Rocky Mountains. Another conspicuous ridge lies immediately north of Lesser Slave Lake.

In the Grande Prairie district, the most distinctive of the lesser heights is Saskatoon Hill. It is about 3000 feet above sea level. Its crest is from 600 to 700 feet above the surrounding farmlands and prairie and it offers a commanding view to the southwest over a wide expanse of country, including the outer spurs and ranges of the Rockies some sixty or eighty miles distant. Forming a division between the Grande Prairie and Spirit River plains is a broad band of

PLATE I

UPPER: View of the southwestern angle of Bear Lake, Grande Prairie, with Benson Point in the right distance. Wide mud flats exist around the head of the bay owing to abnormally low water, June 23, 1944.

LOWER: Typical muskeg of the Northwest, situated about eight miles east of Lesser Slave Lake. Heavy cover of sphagnum moss, Labrador tea and cottongrass, May 29, 1944.

hilly, forested country in which the Saddle Hills figure most prominently. Other conspicuous landmarks are Blueberry Hill, twenty-four miles west of Spirit River, and Clear Hills, situated north of Eureka River.

Many of these major ridges rise from 500 or 600 feet to over 1000 feet above the average level of the surrounding terrain. While most of them are comparatively insignificant, from an overall topographic viewpoint, they become conspicuous in direct proportion to the relative lowness and gentle configuration of adjacent lands. One of the most arresting spectacles in the whole of that territory is the Peace River Valley which varies from 600 to 700 feet in depth. From a point below the town of Peace River, it becomes increasingly spectacular upstream to the westward. At Dunvegan, and other sections upstream, the valley is between 1000 and 1200 feet deep.

Characteristic trees of the region include white spruce (*Picea canadensis*), black spruce (*P. mariana*), tamarack (*Larix laricina*), jack pine (*Pinus Banksiana*), balsam fir (*Abies balsamea*), aspen poplar (*Populus tremuloides*), balsam poplar (*P. balsamifera*), and paper birch (*Betula alba* var. *papyrifera*).

Various species of shrubbery comprise a notable component of the regional flora. Two of the most conspicuous examples are different species, or varities, of willows (*Salix*) and alders (*Alnus*). They are especially notable in association with shoreline habitats adjacent to lakes and streams. Other species of shrubs that have a wide distribution in the region are serviceberry (*Amelanchier florida*), silverberry (*Elaeagnus argentea*), highbush cranberry (*Viburnum pauciflorum*), red-osier dogwood (*Cornus stolonifera*), chokecherry (*Prunus virginiana*), pin cherry (*P. pennsylvanica*), buffaloberry (*Shepherdia canadensis*), snowberry (*Symphoricarpos pauciflorus*), wolfberry (*S. occidentalis*), and Canada blueberry (*Vaccinium canadense*).

Muskegs of varying size are of rather common occurrence over most of the region. Some tracts cover many square miles. These exist on the rolling lowlands as well as on the tops of the many broad ridges and plateaus throughout the territory, though they are very small or absent from most parts of the scattered prairie parklands areas. The dominant growth in these cold, wet depressions embraces black spruce, tamarack, Labrador tea (*Ledum groenlandicum*), sphagnum moss (*Sphagnum capillaceum*), cloudberry (*Rubus chamaemorus*), bog cranberry (*Vaccinium oxycoccos*), dwarf birch (*Betula glandulosa*), and cotton grass (*Eriphorum opacum*) (Pl. I).

ACCOUNTS OF SPECIES

Sorex cinereus cinereus Kerr. Cinereous shrew.—This diminutive insectivore ranges throughout the region, but, during the season of 1944, it appeared to be scarce. Much trapping failed to take it in the country between Athabaska and Grande Prairie. A few examples were collected at Bear, Saskatoon, Ray, Cardinal, and Kinawan Lakes. It was most numerous in the latter locality where seven individuals were taken in sixty trap-nights. Only thirteen, in all, were secured in about 2700 trap-nights. Average measurements, in millimeters, of the six specimens preserved are: length, 97; tail, 40.5; hind foot, 11.9 (min. 90, 41, 11.5; max. 100, 42, 12); average weight, 3.85 (3.5—4.4) grams. The species inhabits both dry deciduous or mixedwood forest, and damp muskegs.

Sorex arcticus arcticus Kerr. Saddle-back shrew.—This shrew is recorded only from Ray Lake, where two specimens were taken, July 6, in a spruce-grown lowland with much underbrush. These measured and weighed, respectively, 122, 45, 13.5 mm., 8.4 grams; and 112, 42, 13.5 mm., 7.3 grams.

Sorex palustris palustris Richardson. Water shrew.—Water shrews were taken only along the margins of Sinclair Lake and Creek, July 9 and 10. Measurements of the three specimens are: 161, 70, 20.2 mm., wt. 13.6 grams; 153, 68, 20.1 mm., wt. 14.2 grams; and 172, 76, 20.1 mm., wt. 15.1 grams.

Myotis lucifugus lucifugus (Le Conte). Little brown bat.—On the evening of July 6, two small bats, thought to be this species, were seen at Ray Lake. Scarcity of bats may be judged from the fact that these were the only examples observed during the entire season.

Euarctos americanus americanus (Pallas). Black bear.—These animals are found in all parts of the territory examined, from Clyde and Athabaska west to British Columbia, with the exception of the more thickly populated country at High Prairie and in the prairie-parklands districts of Grande Prairie, Spirit, and Peace Rivers. Even on the perimeter of these areas, however, occasional stray animals are reported. Aside from these "islands" of settlement, the animals or their signs were seen, or their presence reported by local residents, in every locality where investigations were conducted throughout the season.

Black bears were said to be particularly common in the great wilderness area north of Lesser Slave Lake and also south of the latter in the Swan Hills. It was stated that they were similarly numerous about Sturgeon Lake, especially some distance to the south. Forest fires have ruined much of the country to the north for big game animals of any kind. Numerous signs of the species were observed all along the route of travel from Pipestone Creek, Wapiti River, and southwest to Torrens River, Rocky Mountains. Individuals were noted near Pipestone Creek, in the valley of Nose Creek, and one in the Torrens River Valley south of the sulphur springs. The Indians assert that the animals are plentiful in practically the entire territory. Signs were noted on many occasions in the forested belt west of Grande Prairie to Ray Lake. A settler near Updike Lake assured me that black bears had killed many of his sheep. They are said to be more plentiful well north of this lake than along the highway leading into British Columbia, but occasional individuals are seen even along this busy road. Many inhabit the timbered and brushy terrain of the Saddle Hills and the wild unsettled territory west of Spirit River.

North of Peace River, the first information regarding the species was obtained north of Hines Creek where it is rather commonly noted in the woods about the farms of the scattered settlers. The animals are reported to be especially common in the unmodified wilderness north of Clear Hills. Data regarding their occurrence were secured all over the country north to Flood Lake. Strays are said to work south to the open farmlands below Cardinal Lake and to other points along the pioneer fringe to the northwest. Old and comparatively recent signs were many times personally observed in this district. According to reports, the animals are common along many parts of Peace and Smoky Rivers. An immature was observed by me a few miles east of Watino, an adult near the north end of Kimawan Lake, and an adult and immature along the east shore of Winagami Lake. From all accounts, outstanding bear country obtains over a wide area eastward from the latter lakes and Magliore Lake.

Ursus horribilis Ord. Grizzly bear.—In the early days this species occurred in the Peace River Valley between Dunvegan and the British Columbia border and probably also along most of the length of Wapiti and Smoky Rivers. According to information obtained from the local Indians, it still roams around the headwaters of both of these streams. The best grizzly bear territory is evidently in the adjacent hinterlands of British Columbia, but good bear hunting is said to be obtainable in some western Alberta localities.

It is interesting that grizzlies are also distributed in Alberta far to the east of the Rockies, south of Sturgeon and Lesser Slave Lakes. An elevated plateau, or ridge, evidently extends almost unbrokenly eastward to a point a short distance south of the east end of Lesser Slave Lake. Its eastern expression is known as the Swan Hills. Grizzly bears are evidently distributed in moderate numbers all along this higher terrain east of the latter point. White men and Indians, at Lesser Slave and Sturgeon Lakes, stated that they had shot grizzlies in the hills to the south of these lakes. Mr. R. W. H. Eben-Ebenau, who resides on the northeast shore of Lesser Slave Lake, had in his possession a fine skin from a large grizzly which he shot in the Swan Hills a few years ago. The species is said not to occur in the high, rugged terrain which opposes the Swan Hills on the north side of the lake.

Martes americana actuosa (Osgood). Marten.—This species is now exterminated over large parts of the region. Only negative evidence as to its probable occurrence was gathered all the way from Baptiste Lake to Grande Prairie. Formerly, the species occupied favorable territory throughout. It is said to have been common a number of years ago in the rugged hill country north of Lesser Slave Lake, especially at Marten Mountain, but evidently it exists there no longer. The same may be said of the Swan Hills. Indians at Sturgeon Lake informed me that a few still exist in the spruce forest that covers a high ridge, or plateau, some fifty to sixty miles to the south. Marten are reported to be scarce at the present time over a wide expanse of territory south of Wapiti River. Over-trapping is said to be responsible. Only relatively small numbers are now taken annually, by professional trappers, in the wilder and more remote localities. Most of the catch apparently derives from the foothills and ranges of the Rocky Mountains. The marten was formerly common and well distributed over this entire territory north of Wapiti River and along the Smoky Valley to Peace River. A few are said to occur still in unbroken wilderness tracts at some considerable distance north and south of Sinclair, Albright, and Ray Lakes.

Old settlers stated that the animals, once fairly common inhabitants of Clear Hills and the country southeast to Cardinal Lake, are now extinct in these parts. A few are still found in primitive forest well to the north and northwest of Clear and Whitemud Hills. Broadly regarded, it would appear that the principal strongholds of the species, in whatever numbers still exist in the region at large, are located in the Rocky Mountain sector and on Caribou Mountain. It is probable that in the eastern part of the region (Athabaska to Lesser Slave Lake and perhaps Sturgeon Lake) the race represented was *M. a. abieticola* (Preble).

Martes pennanti (Erxleben). Fisher.—No absolutely satisfactory evidence was obtained to indicate that this species now occurs in any part of the region traversed in the summer of 1944. Rather vague references were made to it, by Indians and whites, in respect to rare and sporadic occurrences in primitive areas far south of Wapiti River, but it is evident from the character of these remarks that the animals are now nearly, if not completely, extirpated over most of the region. An ex-trapper at Cardinal Lake informed me that an occasional individual roamed the uninhabited wilderness well to the north of Clear Hills.

Mustela erminea richardsonii Bonaparte. Short-tailed weasel.—This is the common weasel of the whole region. Information was gathered as to its occurrence in greater or lesser numbers in nearly every working locality throughout the season. Large numbers are taken during the winter by professional and part time trappers. There was general agreement that the animals were markedly less numerous during the winter of 1943–44 than in several previous seasons. Evidently a distinct periodic cycle of relative abundance is characteristic of this as well as several other fur-bearers. It was not collected, but was observed in life at Sturgeon and Sinclair Lakes, Henderson Creek, and at "Two Lakes," on the eastern margin of the Rocky Mountains.

Mustela rixosa (Bangs). Least weasel.—This weasel was not taken and no concrete evidence of its occurrence is available. Nevertheless, however rare, it is known to occur at least locally throughout the whole length and breadth of the region under review. I talked with many trappers, both Indians and whites, who know this diminutive carnivore beyond doubt and who stated that they had occasionally taken the species accidently in sets made for the short-tailed weasel. Apparently reliable evidence of this sort was secured at Baptiste, Lesser Slave, Updike, La Glace, Cardinal, and Flood Lakes. Native hunters assured me that they had taken examples at various times and places between Wapiti River and the Rocky Mountains. It inhabits both parklands and mixedwood forest environments.

Mustela frenata longicauda Bonaparte. Long-tailed weasel.—This prairie form ranges well north of the parklands district about Edmonton and penetrates the forested country beyond Clyde to at least Athabaska River. Mr. F. P. Appleby informed me that it had been trapped between Athabaska and Baptise Lake, and also at the latter locality. I have no evidence of its occurrence westward of that place. Cowan (1939 : 74) stated that long-tailed weasels were taken by trappers at Little Prairie and on the north side of Peace River in east-central British Columbia. He thought they were probably referable to *Mustela frenata oribasa* (Bangs).

Mustela vison energumenos (Bangs). Mink.—This was formerly a common species along most of the streams and lake shores of the entire region; now greatly reduced in numbers in many, if not the majority of, localities. Few localities were visited, with the exception of those located in the semi-open parklands of Grande Prairie and Peace River, in which the animals were not reported as occurring in at least moderate numbers. Definite and apparently reliable evidence was obtained regarding their presence at, or in the neighborhood of, Baptiste, Lesser Slave, Ray, Updike, Sinclair, Cardinal, Flood, Magliore, and Kimawan Lakes. Indians stated that numbers frequent creeks and rivers from the Wapiti southward at least to the foothills of the Rockies. It was not ascertained with certainty whether the animals inhabited streams of the Rocky Mountains proper, but they were said to occur along Nose Creek and tributaries and part of the upper waters of Wapiti River. The species was reported to be fairly common in the great wilderness area north of Clear Hills, between Peace River and British Columbia. Animals from the territory immediately northward from Edmonton are probably intergrades between the present subspecies and *lacustris*.

Gulo luscus (Linnaeus). Wolverine.—According to information obtained, this species was once generally, and at least sparingly, distributed throughout the region as a whole. I visited no part of the country in which the species was claimed still to exist. South of Wapiti River, the Mountain Crees stated that, while the animal was exterminated over wide areas in this region, a stray individual was known to occur in the Rocky Mountains. Mr. Bakken, the postmaster of Dixonville, informed me that a few wolverines inhabited that district thirty to forty years ago, at which time he trapped a single individual. It no longer exists in this immediate territory. There are rumors that a few still occur in the wilderness to the northwest.

Lutra canadensis preblei Goldman. River otter.—The river otter appears to have been exterminated over most of the territory with which this paper is immediately concerned. No definite information regarding its present occurrence was obtained anywhere except in the region southwest of Wapiti River. The Indians asserted that a few of these animals still exist on some streams in the Rocky Mountain foothills and in country to the east, probably along the Kakwa, Smoky, and Hay Rivers.

Mephitis mephitis hudsonica Richardson. Striped skunk.—The striped skunk is found in varying degrees of abundance throughout the country. It inhabits heavily forested territory as well as the parklands of Grande Prairie and Peace River. The animals themselves, their signs, or reports regarding their presence involved nearly every locality studied during the entire season. They were said to be abundant in some areas, of only casual occurrence in others. The species seemed to be more numerous from Athabaska to Grande Prairie than between the latter area and the British Columbia border. South of Wapiti River, it was traced over terrain of successively higher altitudes to about Nose Mountain, but no definite data were secured on occurrence southwest of that point. It is common in some areas north of Peace River.

Vulpes fulva abietorum Merriam. Red fox.—The fox is commonly distributed in all of the Grande Prairie—Peace River Region west to British Columbia and south of Wapiti River to the Rocky Mountains. In the latter territory, several individuals were observed, and their tracks were frequently seen on dusty trails and on muddy or sandy margins of streams. One was heard barking at Torrens River and others at Ray and Sinclair Lakes. Numerous signs were seen west of Spirit River and at Cardinal Lake. In the Eureka River—Clear Hills district, and at Magliore, Kimawan, and Winagami Lakes, the animals were said to be common to abundant. In general, foxes were reported as being plentiful during the past four or five years. At Bear and Saskatoon Lakes, Grande Prairie, local residents stated that foxes were more numerous during the winter of 1942–43 than they had been for many years. Farther to the northeast, the peak was reached in 1941–42. To the east, the animals were reported common to abundant at all working localities between Sturgeon Lake and Athabaska. Most well-informed persons with whom the subject was discussed claimed that the animals were more plentiful in the winter of 1942–43 than for several seasons past. This condition agreed with that existing in territory farther west. Foxes in this eastern portion

of the territory may be referable to *regalis* or they may represent subspecific intergrades between this form and *abietorum*.

Canis latrans latrans Say. Coyote.—Coyotes ranged throughout the whole territory from Edmonton and Athabaska to British Columbia, south of Wapiti River, and on both sides of the Peace. They appear equally at home in the great forested tracts of the north and in the parklands areas of Grande Prairie and Peace River. Occasional individuals were observed. Their spoors were frequently encountered and on many occasions they were heard howling both by day and by night. More coyote signs were observed between Wapiti River and the Rocky Mountains than in any other part of the region. Residents stated that, like the red fox, this species had been increasing in numbers for several years, but was probably on the decline again in 1944. In the whole territory north of Peace River, the animals had been unusually plentiful for several years, particularly during the trapping season of 1943–44. Based on pooled information, it became evident that the same conditions prevailed south of the Peace in the territory embracing Magliore, Kimawan, and Winagami Lakes. In this area, tracks were common, several individuals were observed, and howling was heard so frequently that no doubts could be entertained as to their abundance and wide distribution.

Canis lupus occidentalis Richardson. Timber wolf.—The wolf, like the coyote, is widely distributed in the region. More signs were seen between Wapiti River and Rocky Mountains than elsewhere. Large wolf tracks were frequently met with in dusty trails. Indians and whites asserted that wolves had been more numerous of late years than for a considerable period and that they were still on the increase.

In the Grande Prairie area, an occasional individual crosses the open country from one heavily wooded tract to another, but such an occurrence is comparatively rare. During the past summer, one was seen crossing farmlands a few miles east of Wembley and another between La Glace Lake and Saddle Hills. Westwardly from the Grande Prairie parklands, the species is only moderately common in summer, but is said to become much more numerous in winter. I was informed that the species is comparatively common in the timbered district between Spirit River and the Pouce Coupe agricultural area of British Columbia. Wherever wolves are found, it is stated that they are heavy killers of mule deer and, to a lesser extent, moose. Near the settlements they also kill sheep and cattle. Evidence gathered north of the Peace consistently showed that wolves were becoming increasingly more abundant along the pioneer fringe and deep into the virgin forests to the north. I received many complaints in this district about their depredations on sheep and cattle, particularly from Hines Creek to Clear Hills. Evidently similar conditions obtained in the Kimawan and Winagami Lakes district where identical complaints were heard. A settler at the north end of the former lake told me that his entire flock of sixty-four sheep had been killed by timber wolves and black bears. It was also learned that wolves were common from Smoky River and Sturgeon Lake east to Lesser Slave Lake, especially in the remoter areas. Between the latter locality and Athabaska, the animals are evidently not so common though some are present west of Baptiste Lake and near Calling Lake.

Lynx canadensis canadensis Kerr. Canada lynx.—Indian and white trappers informed me that the species is relatively common in some of the territory about Lesser Slave Lake and west to Sturgeon Lake and Smoky River. Ordinarily, the best districts are some distance north or south of the main highway. The animals were said to have reached a peak abundance in the winter of 1941–42 and since then have been declining in numbers, but one trapper at Sturgeon Lake stated that in his trapping district, far south of the lake, the animals were more numerous in the winter of 1942–43 than for many years past. In primitive areas west of Grande Prairie and south of Wapiti River, the species was said to have been scarce during the winter of 1943–44. This followed the decline in the snowshoe hare population which was stated to have commenced in 1942. Indians asserted that previous to this date the lynx population was at a fairly high level and that scores were trapped or snared from Pinto Creek southwest to Nose Creek and Narraway and Torrens Rivers, Rocky Mountains. While traveling in that region in July, numerous old snare cubbies for lynx were noted along the trail.

Very little information regarding the species was gathered north of Peace River. In such localities as I visited, it appeared that the species was practically exterminated. Before the days of settlement, it was said to have been common all along the northern and western fringes of the Peace River parklands and in adjacent mixedwood forest. At the present time, good lynx country is evidently not reached until the wilderness is penetrated well north of Clear and Whitemud Hills. As in the region south of Wapiti River, it appears that the lynx population in this more northern area began to decline in 1942 or 1943.

Marmota monax canadensis (Erxleben). Woodchuck.—The woodchuck is distributed in varying degrees of abundance throughout practically the entire extent of territory brought under observation. The animals or their burrows were seen in nearly every working locality. In addition, many were observed along roads and trails in intervening areas. South of Wapiti River they occurred very sparingly. I have no definite evidence of their presence in the country southwest of Pinto Creek nor do I know to what elevation they extend in that direction or in the foothills. The species appeared to be scarcer in the territory north of Peace River than south of it.

Citellus richardsonii richardsonii (Sabine). Richardson ground squirrel.—This is a tolerably common inhabitant of the parklands between Edmonton and Clyde. Recently it has steadily worked its way north along the highway in the bush country until a few have reached Athabaska River. Mr. F. P. Appleby informed me that he had seen a few in fields west of Athabaska and two at the south end of Baptiste Lake during the summer of 1942.

Citellus tridecemlineatus tridecemlineatus (Mitchill). Striped ground squirrel.—This species is found sparingly north of Edmonton to the vicinity of Athabaska River. It occupies grassy and brushy areas and the borders of fields between the town of Athabaska and Baptiste Lake. A few are found also for some distance east of the former point. On August 25, I saw an individual cross the highway near the northeast angle of Baptiste Lake. So far as I am aware, this is the northernmost record of the species in Alberta.

Eutamias minimus borealis (Allen). Least chipmunk.—The geographical distribution of this little quadruped embraces the whole region. It was seen in the majority of working localities during the season, from Clyde and Athabaska west nearly to British Columbia, but was not recorded within the farming-parklands districts of Grande Prairie and Spirit River, except at La Glace Lake. In many places the species is evidently very scarce, but, again, it may be locally common. Local distribution and relative abundance is, therefore, seen to be markedly irregular. South of Wapiti River, the animals were fairly common to the vicinity of Nose Mountain, but were scarce from there to the southwest. North of Peace River, many were seen from the Hines Creek–Clear Hills district eastwardly to Flood and Cardinal Lakes and the town of Peace River. They were well represented in most areas south of the river via McLennan to High Prairie. The three specimens collected at Lesser Slave Lake, Pipestone Creek, and Sinclair Lake, respectively, have the following measurements and weights: male, 210, 96, 30.4 mm., wt. 46.5 grams; female, 212, 100, 32 mm., wt. 43.1 grams; female, 210, 102, 31 mm., wt. 37.7 grams.

Tamiasciurus hudsonicus preblei Howell. Red squirrel.—This squirrel occurs locally throughout the entire territory north and west of Edmonton to the Rocky Mountains. Apparently owing to excessive hunting and trapping of late years for the fur trade, the species was found extremely scarce or absent in the great majority of localities. It was seen nowhere in the poplar parklands of Grande Prairie, Spirit, or Peace Rivers. These may be interpreted as natural, local breaks in its geographic distribution. The same cannot be said of eminently favorable, coniferous forest areas where the species was either reduced to a very low numerical level or was evidently wiped out. The only territory in which the animals were seen, ranging in status from common to abundant, was in the remote wilderness country southwest of Wembley. For a considerable distance below Wapiti River, the animals continued scarce and then began to appear in increasing numbers.

Glaucomys sabrinus (Shaw). Northern flying squirrel.—I saw none of these animals during the season. Information secured from trappers in many localities indicates that they

are generally, but sparingly, distributed over most of the region. Professional trappers take many accidently in cubby trap-sets designed for the valuable fur-bearers such as weasel, mink, and marten. Indians living in the country south of Wapiti River stated that practically every winter a few were caught in this way in different parts of the territory, including Rocky Mountains. Flying squirrels occupying the latter region and that northward (to the west of Grande Prairie) are in all probability *G. s. alpinus* (Richardson) while those to the east, probably beginning at about Smoky River, are referable to *sabrinus* (Shaw). No data were secured to suggest the occurrence of flying squirrels in the semiopen poplar parklands of Grande Prairie, Spirit, and Peace Rivers, but enough evidence was collected to show that they inhabit all surrounding mixedwood forest.

Castor canadensis canadensis Kuhl. Beaver.—The beaver is sparingly distributed throughout the region. It apparently has been exterminated or reduced to a state of great scarcity over large areas. No sign of the animals was observed anywhere between Athabaska and Grande Prairie. At both Lesser Slave and Sturgeon Lakes, I was told by woodsmen that a few occur in lakes and streams in remoter parts of the wilderness. All were in agreement that the species had been greatly reduced in numbers, as compared with primitive times, or had actually suffered extirpation in some districts. The species was first met with in the Grande Prairie area where a family was located on Bear Creek below the lake of the same name. Another dam was situated on the creek draining La Glace Lake. Between Grande Prairie and the western border of the province, it was said that a few scattered establishments still existed on creeks north and south of the highway. No sign of them was personally observed in this district. The same was true of the territory traversed from Wembley to the Rocky Mountains. Indians and whites stated that only a few scattered families are left in that region. Based on evidence gathered north of Peace River, it is evident that similar conditions exist in a wide expanse of country north of the prairies, between the latter stream and the border of British Columbia. It may well be that the animals are locally more numerous in some districts far to the north, but in the region as a whole, they continue to decline in numbers.

Peromyscus maniculatus borealis Mearns. Deermouse.—This is the form which inhabits the whole of the region under consideration, including the Rocky Mountain sector of Torrens River. Relative abundance varied markedly from one locality to another. In some places the animals were extremely scarce or apparently absent while in others they were common to abundant. At no other points were they found so abundant as at Magliore, Bear, Saskatoon, and Sinclair Lakes where forty-six, forty-two, thirty, and forty individuals, respectively, were taken in one hundred sixty trap-nights at each place. The species was rare at Henderson Creek. It was definitely scarcer in the territory from Baptiste Lake to Sturgeon Lake than in the Peace River–Grande Prairie area. At Cardinal Lake, relative abundance was apparently about midway between that existing at Faust, Lesser Slave Lake, and about the lakes in the southern portion of Grande Prairie. Average measurements and weights of fourteen preserved examples are: 170.2, 78.1, 20.1 mm., wt. 19.2 grams; extremes, 162, 80, 19.5, and 185, 85, 21 mm., wts. 15.3 and 24.6 grams.

Neotoma cinerea drummondii (Richardson). Bushy-tailed woodrat.—Fundamentally, this is an animal of the Rocky Mountains and foothills, but in some places its range extends to the east of that section. The first evidence of its occurrence was secured at Pipestone Creek and Wapiti River, south of Wembley. Signs (chiefly comprising nests among the roots of large spruces) were noted at Pinto Creek and near Nose Creek, west of Nose Mountain. Its presence was not detected west of Grande Prairie though Cowan (1939: 81-82) recorded the species as occurring at Tupper Creek and Charlie Lake, B.C. I was told on good authority that the species inhabits the Peace River Valley as far eastward, at least, as Dunvegan. A resident at Dunvegan stated that the animals were common about the buildings a few years ago, but were recently exterminated with traps and poison.

Synaptomys borealis chapmani Allen. Lemming vole.—This species is apparently scarce and local in occurrence. Extensive trapping in apparently favorable habitats at numerous places, in the Rockies and elsewhere in western Alberta, resulted in the capture of but one,

a male. This was taken in a moist spruce woods near the shore of Ray Lake, July 6. Its measurements are: 115, 22, 18 mm., wt. 22.9 grams. It has been referred by Dr. R. M. Anderson to *chapmani*, being paler and grayer than Wood Buffalo Park *borealis* and Yukon Territory *dalli*. It compares fairly well with a series of *chapmani* from Jasper Park.

Clethrionomys gapperi athabascae (Preble). Red-backed vole.—All of the region examined in the summer of 1944 falls within the range of this subspecies. Like *Peromyscus*, it was found to vary greatly in relative abundance in different localities. In a few places it was difficult to secure specimens whereas in others it ranked from moderately common to abundant. This vole was found more numerous at Sinclair and Kimawan Lakes than elsewhere. Forty individuals were taken in one hundred sixty trap-nights and fourteen in sixty trap-nights, respectively. It was much less numerous or even markedly scarce in other localities. Specimens were preserved at the majority of working areas. Two specimens in the dark pelage phase were collected at Sinclair Lake and Henderson Creek, respectively. The rarity of this color phase may be judged from the fact that these are the only ones I have ever seen in Alberta after many years of field work. A female containing six embryos averaging 18 mm. in length was taken at Sinclair Lake on July 8. This individual measured 152, 46, 18 mm., and weighed 34.7 grams. Average measurements of seventeen specimens from widely scattered localities are: 138.6, 38.3, 18.6 (min., 132, 34, 17.5; max., 152, 46, 18) mm.; average weight, 24.5 grams (min., 16.7; max., 34.7).

Microtus pennsylvanicus drummondii (Audubon and Bachman). Meadow vole.—These voles occur throughout the region. From all accounts, they are excessively abundant at times, but during the summer of 1944 they appeared to be at a low level of abundance. In nearly every locality they were either so scarce that no examples were taken or they occurred only sparingly. The largest number collected was at Saskatoon Lake (eight in 160 trap-nights). Examples were taken at Baptiste, Lesser Slave, Sturgeon, Bear, Saskatoon, Ray, Sinclair, Cardinal, and Magliore Lakes. Five preserved examples average, 142.6, 39.6, 18.4 mm. (min., 116, 27, 16.5; max., 156, 46, 19.5); average weight, 29.2 grams (min., 15.7, max., 38.3). All specimens check with *drummondii* in skull characters as well as dark color and small size; two specimens are somewhat abnormally reddish, but there is much individual as well as local variation.

Ondatra zibethica spatulata (Osgood). Muskrat.—The muskrat is generally distributed from Athabaska to British Columbia and throughout the Peace River–Grande Prairie Region. According to personal observations and testimony of local residents, the muskrat population is now generally reduced to a low level. Few were seen. This is partly the result of greatly lowered water levels over most of the region. It applies particularly to the lakes and streams of the Grande Prairie–Peace River district. In some localities, the residents attribute the great reduction in numbers to over-trapping. Disease may have been involved in some instances, physical conditions in others. Many sloughs and streams have dried up and most of the larger lakes have subsided from four to eight feet, spoiling much of the emergent aquatic plant cover. At Cardinal and other lakes, muskrats were once abundant, living in bank dens. This has now become impossible since the banks are well above water level and mud or sand flats intervene. The same is true of Kimawan Lake where the animals were formerly plentiful, but are now practically wiped out. It was claimed by local residents that, owing to rapid subsidence of the water, the remaining muskrats froze to death in their bank runways and dens during the winter of 1942–43.

The few examples recorded during the season were seen at Buffalo Bay, Lesser Slave Lake, at Sturgeon, Saskatoon, Deep, Ray, Sinclair, and Updike Lakes and Henderson Creek. More individuals were observed at Sinclair and Updike Lakes than at any other point, indicating that they were still fairly common there. A local woodsman informed me that he trapped about four hundred muskrats at the latter lake during the season of 1943–44. He judged that he had left about one hundred individuals for breeding. The Indians assert that the muskrats of the mountain territory are darker and average somewhat smaller than those at lower elevations to the east and north.

Only one specimen, an adult male taken at Ray Lake on July 4, was collected in this region.

Measurements are: 584, 260, 80 mm., wt., 2.25 pounds. It is very red and pale for this form, but in skull characters and external measurements it agrees with *spatulata*. Dr. Anderson informs me that it is much redder than Yukon specimens of this subspecies.

Mus musculus domesticus Rutty. House mouse.—The house mouse is probably generally distributed in settlements and farm buildings throughout the region. A male was trapped in the woods at Sturgeon Lake on June 16. Measurements are: 155, 74, 17 mm., wt. 15.6 grams.

Zapus hudsonius hudsonius (Zimmermann). Meadow jumping mouse.—This mouse is at least sparingly distributed from Edmonton north to Athabaska and westward to the Peace River territory. It was probably fortuitous that the animal was not found in the Grande Prairie area because, under nearly identical, physical conditions, it was taken north of Peace River. Live examples were noted at Baptiste and Sturgeon Lakes. Specimens were collected at Faust, Lesser Slave Lake, and at Cardinal and Magliore Lakes. Average measurements and weights of four specimens are: 209.7, 128.5, 29.9 mm.; wt., 17.2 grams.

Zapus princeps princeps Allen. Mountain jumping mouse.—During the 1944 investigations, this mouse was found in the extreme western part of Alberta. Measurements of the specimens taken are: Ray Lake, male, 225, 140, 30 mm., wt. 17.7 grams; and Sinclair Lake, female, 218, 129, 30 mm., wt. 21 grams. In addition to those trapped, three others were flushed from the grassy, southern border of "Two Lakes" on the evening of July 19. The Ray Lake specimen was trapped in brushy spruce woods near the shore and the one at Sinclair Lake in dry poplar woods some distance from the water.

Erethizon dorsatum dorsatum (Linnaeus). Porcupine.—The porcupine was personally observed in life only at Baptiste and Ray Lakes and between Pinto Creek and Torrens River in the Rockies. An adult skull, from Sturgeon Lake, and an immature specimen, taken at Ray Lake on July 4 and forwarded to the National Museum, Ottawa, were referred by Dr. Anderson to *E. d. dorsatum*. The latter specimen is a female measuring 510, 145, 82 mm., wt., 5.5 pounds. A very small young one, observed at Nose Creek directly west of Nose Mountain, was very dark with white to slightly creamy white quills with black tips. An adult seen in the same locality was also generally dark, but with a little pale yellow in the quills. Cowan (1939: 87-88) took two specimens, which he refered to *nigrescens*, at Tupper Creek, B.C. He remarked: "A comparison of these specimens with series from Ontario and from north central British Columbia places the Peace River material unequivocally with the latter."

Lepus americanus Erxleben. Snowshoe hare.—The snowshoe hare, in one form or the other, occupies the entire region. It was found markedly scarce throughout. In many localities only one or two individuals were seen after several days of active investigations in all types of areas. In other localities, as at Sinclair, Ray, Updike, Cardinal, Kimawan, and Winagami Lakes, not a single one was detected. In relation to the time involved, more were seen at Bear and Saskatoon Lakes, Grande Prairie, than at any other locality northward from Wapiti River. Southwest of Iroquois Creek, the animals were slightly more numerous than in other localities to the north and east (exclusive of Bear and Saskatoon Lakes areas), but even here, with rare exceptions, individuals were noted only at wide intervals. At "Two Lakes," the animals appeared to be locally common along the south shore of the eastern lake where an adult female was collected on July 24. It measured 490, 38, 142 mm., wt., 5 pounds. A juvenile, taken at Pinto Creek on July 27, measured 205, 18, 56 mm., wt., 174.2 grams.

Old signs were common in most localities. From Baptiste Lake to Sturgeon Lake, residents were generally in agreement that the animals were plentiful and apparently at the height of their cycle of abundance during the winter of 1942–43. Some placed this as occurring somewhat earlier. In the Grande Prairie–Peace River territory and south of Wapiti River, Indians and whites varied a little in their opinions of the beginning in the population decline. Some stated that it occurred in 1941, others, 1942. It seems certain that, both in respect to time and degree, there is an appreciable disparity in the reduction of numbers in different parts of a wide geographic area.

It is not known where the zone of intergradation occurs, in this area, between the forms

americanus and *macfarlani*. It seems probable that the former is represented from about Lesser Slave Lake eastward and south while *macfarlani* characters are at least most pronounced to the westward. The "Two Lakes" adult is referred to the latter subspecies by Dr. Anderson on the basis of color and size. It is assumed that all territory to the north is occupied by this form. Cowan (1939: 88–89) stated that specimens from the Peace River territory of British Columbia ". . . display characters intermediate between *L. a. americanus* and *L. a. macfarlani*, but are more nearly referable to the latter race."

Cervus canadensis Erxleben. Wapiti, or Elk.—The elk once ranged over a wide expanse of country within the region under discussion, but it has long since been exterminated in most of the territory. According to the statements of Alexander Mackenzie (1802), the animals were abundant in the Peace River region about one hundred fifty years ago. I have no knowledge as to when the last were seen there. Occasional antlers are still found in the lands adjacent to the Peace, at Grande Prairie, and to the west and south. Oldtimers in this territory stated that the animals were once common there and in the country bordering Wapiti River, as is indicated by the name of this stream. At the present time there is said to be a number in western Alberta and the adjoining portion of British Columbia toward the head of Wapiti River, roughly around and between the lower portions of Narraway River and Belcourt and Red Deer Creeks. No sign of the species was seen during the trip to Torrens River. Mountain Crees, with whom I talked, expressed the opinion that a few still existed in the mountains between the headwaters of Kakwa and Smoky Rivers. These are inferentially referable to *C. c. nelsoni*.

Odocoileus virginianus (Boddaert). White-tailed deer.—On two occasions I heard of the presence of white-tailed deer in the Peace River region, but I still accept the testimony with reservations until more concrete evidence is at hand. This country is far beyond the ordinary known range of this species. However, I shall submit the evidence for whatever it may be worth.

At Cardinal Lake, a professional trapper informed me that he had several times seen "white-tails" in this locality and also north of the Whitemud Hills. He was positive in his declaration that there was no possibility of error in the identification as he had not only observed the large white "flags" as they went bounding away, but had shot two or three examples and closely examined them. He also stated that the animals were rare as compared with the numbers of mule deer. Substantially similar statements were made by a settler at Magliore Lake in regard to the presence of a few "white-tails" in that district. He was also as equally positive as the Cardinal Lake trapper in respect to correct identification.

Odocoileus hemionus hemionus (Rafinesque). Mule deer.—This species was generally distributed over the entire region covered during the summer of 1944. Numerical status varied markedly in different localities, ranging from that of only casual occurrence to a state of relative abundance. Signs of the animals, or the animals themselves, were observed in nearly all localities. In addition, many were seen while we motored from one area to another.

Mule deer were well represented from Baptiste Lake to Sturgeon Lake and Smoky River. On the basis of local accounts, it would appear that the species is particularly common in the rugged terrain north of Lesser Slave Lake and in the Swan Hills to the south. Two were noted at the northeast angle of the lake and several were seen between Triangle and Smoky River. The animals were said to be fairly common and universally distributed northward from Triangle to Peace River. Only two were observed in this area, but spoors were seen on numerous occasions about Winagami, Kimawan, and Magliore Lakes. Many are said to resort to the wild broken lands of the Smoky River Valley west of these points.

As would naturally be expected, comparatively few animals or their signs were seen in the parklands farming areas of Grande Prairie, Spirit River, and Peace River. Nevertheless, numbers occur there in brushy tracts about the lakes and along streams on both sides of the Peace. Many are found in the wilderness area between Spirit River and Pouce Coupe. Three were observed in the Cardinal Lake locality, two at Henderson Creek, and one each at Bear and Saskatoon Lakes. In this district, farmers stated that deer were sometimes seen crossing open fields, and prairies from one patch of woodland to another. No actual

examples were sighted westward from Hythe, but residents said that the species was fairly well distributed in that territory. Spoors of the animals were noted at Sinclair, Brainard, Updike, and Ray Lakes. The species is common to abundant over most of the country south of Wapiti River to the Rocky Mountains.

There can be no doubt as to the common distribution of these animals over the region as a whole. Insufficient data were secured which would enable one to approximately determine the northward limits of distribution in this region, but the animals probably occur as far north, at least, as the upper waters of Hay River. To the east of Caribou Mountain they are known now to have extended their range north as far as Great Slave Lake. In recent times they have increased in numbers and are working farther north.

Alces americana americana (Clinton). Moose.—Like the mule deer, this species is found in greater or lesser abundance throughout the entire region, coextensive with heavy forests. In many areas, and perhaps for the territory as a whole, it is the most abundant of big game mammals. So far as I know, the species is found nowhere in the true parklands-prairie country of Peace and Spirit Rivers and Grande Prairie, but it does occur in all wilderness tracts of thick timber on all sides of these isolated prairielands. In some places it is necessary to penetrate the forest for many miles in order to reach good moose country while, conversely, the animals are sometimes found close to, or on the very margins of, settled areas. An outstanding example of this was the sighting of a cow moose in August along the west shore of Kimawan Lake within a few hundred yards of bush farms, six miles from the town of McLennan.

Between the prairies, mentioned above, and the British Columbia boundary, moose are fairly well distributed according to the statements of several settlers with whom the subject was discussed. Occasional animals are shot even close to the roads leading west to Pouce Coupe from the Grand Prairie and Spirit River areas, respectively. None was personally sighted in this territory, but tracks were seen at Henderson Creek and Updike Lake and also at a point about two miles south of Ray Lake. Beyond the farmlands, south of Wapiti River, the species is almost universally distributed.

No moose, nor their signs, were observed within the investigated areas north of Peace River, but the country was not penetrated deeply enough north of the agricultural area to reach regular moose country. I was informed, however, that the animals were moderately common to plentiful north of Clear and Whitemud Hills and that they came within a few miles of Flood Lake, North Star, Notikewin, and other points along the Grimshaw-Yellowknife trail. Farther north and west they are presumably present in considerable numbers. A few are said to occur along Peace and Smoky Rivers and it is evident from reports that a particularly excellent moose territory obtains over a wide expanse of wilderness east of Peace River, Magliore, Kimawan, and Winagami Lakes, and north of Lesser Slave Lake. In the latter district, many accounts of good hunting were heard with respect to territory north of the lake as well as in Swan Hills and tracts to the south and west. To the eastward, the species is distributed almost as far as Baptiste Lake, but it is more plentiful north and west of Athabaska River.

Rangifer caribou sylvestris (Richardson). Woodland caribou.—It is evidently this race that occurs irregularly in some parts of the region from Lesser Slave Lake westward as it does in Wood Buffalo Park and Caribou Mountain farther north. North of the above-named lake, the species is said to occur in some numbers, but it is apparently absent in all parts of the territory to the south. During midwinter, it becomes more numerous in the range of hills immediately north of Lesser Slave Lake, thus indicating that some of these animals, at least, indulge in a more or less local north-south movement between summer and winter ranges. It is possible that many of them derive from the much higher terrain of Birch Mountain, to the northeast, where they spend the summer and autumn.

A trader at Eureka River informed me that woodland caribou occur both summer and winter some little distance north of Clear Hills. Occasionally they have been known to wander as far south as these hills during the winter months. A settler east of Ray Lake stated that caribou have been seen within a few miles of this lake in winter and that they

wander in from the west or southwest. It was his opinion that they came from the Rocky Mountains and returned there in the summer. The specific, or subspecific, identity of these caribou is not known.

According to the Indian inhabitants, the caribou formerly ranged rather widely in the forests of extreme western Alberta, south of Wapiti River. It now appears to be nearly if not entirely exterminated over most of this territory, though odd strays are sometimes met with in winter. These are, presumably, wanderers from the more remote fastnesses of the Rockies. The natives say that in the latter country the animals are still of fairly common local occurrence. All or part of these western animals may be referable to *Rangifer fortidens* Hollister.

Bison bison athabascae Rhoads. Wood bison.—It is evident from the statements of Alexander Mackenzie (1802) that this animal was abundant along Peace River a century and a half ago. It also ranged over the plains of Spirit River, Pouce Coupe, and Grande Prairie. A lengthy historical account of the wood bison in the Northwest is to be found in the writer's published monograph of 1941. These animals were exterminated in the Peace River–Grande Prairie territory about 1875.

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National Parks Bureau, Dominion Public Building, Winnipeg, Manitoba. *Received Jan. 14, 1947.*

AN UNDESCRIBED COTTON RAT FROM NEW MEXICO

By Marshall C. Gardner

During the course of a revision of the North American cotton rats (Genus *Sigmodon*) another hitherto unrecognized subspecies was discovered. It is described below.

The color names and symbols are those used in *A Dictionary of Color*, by A. Moerz and M. Paul (McGraw-Hill Book Company, Inc., New York, 1930). Although *Color Standards and Color Nomenclature* (R. Ridgway, 1912) has for many years been the standard for mammalian taxonomy, I consider its continued use to be undesirable since many of its colors in the old plates have become worn and altered in tone. In addition, it has long been out of print and probably will not be reprinted. Moreover, Moerz and Paul have greater variety of colors, particularly in the grays and browns so important in mammalogy.

Sigmodon minimus woodi, subsp. nov.

Type specimen.—Adult male, skin and skull, no. 266327, U. S. National Museum (Biological Surveys Collection); collected December 1, 1940, by David Wood, Jr.; original number, 12; Biological Surveys miscellaneous no. 30005X.

Type locality.—East side of the Rio Grande, fifty-one miles south of Albuquerque (near Bernardo), altitude 5,000 feet, Socorro County, New Mexico.

Geographic range.—Known only from region of type locality, Upper Austral life zone.

Diagnostic characters.—A small, dark subspecies, most closely allied to *Sigmodon minimus goldmani*. In a comparison of the types of *goldmani* and *woodi*, the upper parts of the latter are less gold and the underparts are more cinnamon. In skull characters, *goldmani* is greater in cranial breadth and in the width of the posterior halves of the nasal bones. The subspecies *woodi* is greater in zygomatic breadth and in the distance between the external edges of the upper third molars. In comparison with *S. m. minimus*, this new race is much darker and larger. No comparison is required with *S. h. berlandieri*.

Color.—Type: Upper parts, inca gold (XI J-7) mixed with black; underparts, walnut taffey (XII E-6); tail unicolor, close to African brown, but color not named (VIII E-5), with the exception of the extreme white tip.

Skull.—Similar to that of *S. m. goldmani* with the exceptions noted above, but smaller.

Measurements.—Type: Total length, 257 mm.; tail vertebrae, 101; hind foot, 31. Two other adult males: 235, 237; 95, 95; 31, 31. Skull of type: Condylo-incisive length, 32.8; length of anterior palatine foramina, 7.8; palatal bridge, 5.7; nasal length, 12.1; zygomatic breadth, 20.1; least interorbital breadth, 4.55; cranial breadth, 13.5; maxillary tooth row, 6.1; distance between outer edges of upper third molars, 8.15. Two other adult males and three adults of undetermined sex: 32.0, 31.65, 31.65, 31.5, 31.7; 7.4, 7.4, 8.0, 7.6, 7.7; 5.55, 6.1, 5.9, 5.7, 5.9;—, 11.6, 11.5,—, —; 19.4, 20.0, 19.5, —, 19.5; 4.7, 4.75, 4.6, 4.88, 4.8; 13.3, 13.4, 13.7, 13.5, 13.6; 6.1, 6.2, 6.2, 5.85, 6.2; 8.0, 8.1,—,—, 8.0.

Remarks.—The color characteristics of this new race are complicated by the presence of varying degrees of albinism in some of the specimens examined. Two of the other cotton rats examined also have white-tipped tails and one of these has a clear white V-shaped streak running from the under surface of the face and neck to a point two thirds down the underside. Two specimens are without any traces of albinism. It is not concluded that albinism is a characteristic of this new race, and the designation of a specimen with a white-tipped tail as the type was done only because it best typifies the diagnostic characters.

Specimens examined.—Eight, from the following localities in New Mexico: Type locality, 1; Bernardo (opposite, on east side of the Rio Grande), 7.

U. S. Fish and Wildlife Service, Washington, D. C. *Received July 26, 1947.*

GENERAL NOTES

MAMMAL TYPE SPECIMENS FORMERLY IN THE RAFFLES MUSEUM, SINGAPORE

Shortly before the recent war, the director of the Raffles Museum, Singapore (the late F. N. Chasen), agreed to transfer the mammal types in the reference collection to the British Museum of Natural History in London. It was felt that they would be safer there than in a tropical climate. They would also be available to a greater number of interested persons.

Unfortunately the types had not been sent when hostilities broke out in Europe, in 1939, and it was then decided, in view of the risks of loss at sea, to keep them in Singapore until after the end of the war. When the Japanese attacked Malaya in December, 1941, the types were packed in boxes and moved to the herbarium at the Botanic Gardens. It was felt that they were not safe in the Raffles Museum, in view of its proximity to the British military headquarters at Fort Canning. Actually the Japanese never hit the museum with a bomb, though one shell penetrated the library and several others exploded in the grounds. Shortly after the capitulation of the British forces on February 15, 1942, such boxes as could be found were moved back to the museum by Dr. E. J. H. Corner, a member of the staff of the Botanic Gardens.

No list of these types, compiled in Singapore, survived the war. It is doubtful if one was ever made. In 1945, the director of the British Museum drew the attention of the British Military Administration in Malaya to Mr. Chasen's promise to transfer the specimens, and asked again for them. On my arrival in Singapore early in 1947, I catalogued the types available in the Raffles Museum and examined the reference collections thoroughly for any that might never have been removed from them. The specimens thus located were sent to the British Museum in June.

When the director of the British Museum wrote, in 1945, he sent a list, compiled in London, of the types that were believed to be in Singapore. Subsequent investigations have modified this list slightly. In its revised form it includes 113 mammals. Types of ninety-nine of these were found during the search in March, April, and May of 1947, but the specimens of the remaining fourteen, listed below, appear to be missing. Enquiries have been made in the Museums of Leiden, Amsterdam, Buitenzorg, and Kuching, and they are not known to be in any of these collections. They are also not included in the Catalog of the Type Specimens in the U. S. National Museum (Poole and Schantz, 1942, U. S. Nat. Mus. Bull., no. 178). No mammal skins were sent to Japan from Singapore by the Japanese authorities during their occupation of Malaya. It would seem, therefore, that these types must have been lost during the moves to and from the Botanic Gardens in 1942. Unless this note should lead to their discovery in some quite unexpected collection, they must be presumed to have disappeared for all time.

A catalog of the specimens transferred to the British Museum is being published in the Bulletin of the Raffles Museum (No. 19, 1948), together with the list given below of the types presumed to be lost.

Tupaia glis jacki Robinson & Kloss. 1918.—Jour. Fed. Malay States Museum, 8: 15. Siolak Daras, Korinchi Valley, West Sumatra.

Hipposideros ridleyi Robinson & Kloss. 1911.—*Ibid.*, 4: 241. Singapore Island.

Sciuropterus (*Petaurillus*) *kinlochii* Robinson & Kloss. 1911.—*Ibid.*, 4: 171. Kapar, Selangor, Malay States. (Note, Chasen (1940. Bull. Raff. Mus., no. 15: 116) gives this as *Petaurillus kinlochii* (Rob. & Kl.).)

Rattus rattus payanus Chasen & Kloss. 1931.—Bull. Raff. Mus., no. 5: 79. Paya Island, in the Straits of Malacca.

Rattus rattus jemuris Chasen & Kloss. 1931.—*Ibid.*: 78. Jemur Island, Aroa group, in the Straits of Malacca.

Rattus rattus kunduris Chasen & Kloss. 1931.—*Ibid.*: 77. Kundur Island, Rhio Archipelago.

Rattus rattus mangalumis Chasen & Kloss. 1931.—*Ibid.:* 88. Mangalum Island, North-West Borneo.

Rattus concolor equile Robinson & Kloss. 1927.—Jour. Fed. Malay States Mus., 13: 209. Ongop Ongop, Idjen Massif, East Java (altitude 5,700 feet).

Epimys fraternus Robinson & Kloss. 1916.—Jour. Straits Branch Royal Asiatic Soc., no. 73: 373. Korinchi Peak, West Sumatra (altitude 4,700 feet). (Note, Chasen, *Ibid.:* 176, gives this as *Rattus rapit fraternus* (Rob. & Kl.).)

Rattus canus malaisia Kloss. 1931.—Bull. Raff. Mus., no. 5: 105. Near Kuala Lumpur, Selangor, Malay States.

Tragulus kanchil angustiae Kloss. 1918.—Jour. Fed. Malay States Mus., 7: 254. Victoria Point, Tenasserim.

Tragulus kanchil penangensis Kloss. 1918.—*Ibid.:* 253. Penang Island, off Province Wellesley, Straits of Malacca.

Cervus unicolor oceanus Chasen & Kloss. 1927.—Proc. Zool. Soc. London, 1927: 818. Siberut Island, Mentawi group, West Coast of Sumatra.

Muntiacus muntjak montanus Robinson & Kloss. 1918.—Jour. Fed. Malay States Mus., 8: 69. Korinchi Peak, Sumatra (altitude 7,300 feet).

C. A. Gibson-Hill, *Raffles Museum, Singapore.* *Received Sept. 30, 1947.*

FOOD OF CALIFORNIA SEA-LIONS

According to published accounts (see references) the stomach contents of at least fifty-eight sea-lions, *Zalophus californianus*, have been examined by naturalists. We have recently examined the contents of four others, described below. Our specimens were collected in southern California; two of them by us and two by the California Division of Fish and Game.

No. 1297, female, 23 October 1943, found dead on beach 3 mi. N La Jolla, length 1690 mm. Stomach contents: about 100 cc.; 26 small rocks up to 1 inch in diameter; beaks and "pencils" of at least 21 small squids.

No. 1298, male, 26 November 1943, found dead on beach 3 mi. N La Jolla, length 1680 mm. Stomach contents: wet, 5.67 kg. (12.5 pounds); remains of 36 whole or nearly whole herring, *Culoea pallasii*, 6–10 inches long; also about one liter of bones and fragments representing over thirty herring of smaller size.

No. 1369, female, 5 December 1946, shot on Santa Barbara Island, length 1735 mm., weight 170 pounds. Stomach contents: parasitic roundworms; one smooth rock the size of a walnut, weight 42 grams.

No. 1370, female, 5 December 1946, shot on Santa Barbara Island, length 1715 mm., weight 183 pounds. Stomach contents: parasitic roundworms; five rocks the size of walnuts, total weight 130 grams.

REFERENCES

Bonnot, Paul. 1929. Report on the seals and sea lions of California. Calif. Div. Fish and Game, Fish Bull, no. 14: 21. [Five specimens without food and three with mother's milk, from southern California, 8–28 June 1928.]

———. 1932. A note on the fishing of the California sea lion. Calif. Fish and Game, 18, no. 1: 98–99. [One specimen from Baja California, 8 August 1931.]

Dyche, L. L. 1903. Notes on the food habits of California sea lions (*Zalophus californianus* Lesson). Trans. Kan. Acad. Sci., 18: 179–182. [Twenty-five specimens from central California, June–September 1899.]

Merriam, C. Hart. 1901. Food of sea lions. Science, n.s., 13, no. 333: 777. [No exact data. "A few years ago . . . I took the trouble to examine the stomach contents of a large number of these animals. . . ." Whether Merriam was working independently or whether he was reporting on the findings of Dyche in 1899 is not clear from Merriam's article.]

RUTTER, CLOUDSLEY, ROBERT E. SNODGRASS, and EDWIN C. STARKS. 1940. Report on the sea lion investigation, 1901. Rept. U. S. Comm. Fish and Fisheries for 1902: 116–119. [Twenty-four specimens from southern California, 23 July–6 August 1901.]—VICTOR B. SCHEFFER AND JOHNSON A. NEFF, *U. S. Fish and Wildlife Service, Seattle, Washington. Received May 8, 1947.*

MOUNTAIN LION PREYS ON BIGHORN

Evidence of the predation on desert bighorn (*Ovis canadensis nelsoni*) by a mountain lion (*Felis concolor*) was found on the San Bernardino National Forest in Southern California in March 1947. Forest Officer Elwood M. Stone found portions of a recently killed bighorn, including the complete head. Tracks in the immediate vicinity identified the attacker as a mountain lion and showed that a struggle had taken place before the bighorn had succumbed.—F. P. CRONEMILLER, *U. S. Forest Service, San Francisco 11, California. Received July 8, 1947.*

GOLDEN EAGLE KILLS BIGHORN LAMB

On the morning of February 19, 1947, I arrived at the top and south end of Goat Mountain, via Rock House, in Bear Canyon, New Mexico at 10:13 A.M. Immediately, through binoculars, I observed a group of fourteen bighorn sheep (*Ovis canadensis mexicana* Merriam) at a distance of approximately 100 yards. The sheep included ten ewes, two yearlings, and two lambs. Two of the ewes with the lambs appeared to be in good condition. The other ewes in this group had very large udders, indicating lack of nursing and the probable loss of their young. At 11:55 A.M. one ewe was seen in the canyon between Goat and Bennett Mountains. This ewe appeared to be sick and was kept under observation for eleven minutes before she lay down to give birth immediately to a lamb. She remained prone for six minutes, whereupon she arose to nudge the lamb under a protective bush some three feet distant, an act requiring about three minutes. She then climbed atop a cliff about thirty feet above her lamb and lay down in a position from which she could keep the lamb constantly within her sight. One hour and three minutes later she arose and descended the cliff to the lamb. Upon the ewe's arrival, the lamb arose, walked wobbly for about three feet to the mother, and began to nurse. For about three minutes, it fed completely concealed beneath the ewe until the latter walked away to watch her offspring from a distance of about ten feet. The lamb returned to the protection of the bush and again lay down. The ewe then resumed her resting position atop the cliff.

I observed the ewe and lamb forty-five minutes longer before continuing my journey in search of more sheep along the south end of Bennett Mountain, where at 2:30 P.M., eight rams were seen at a point some one and one-half miles from the ewe and lamb in question. During the observations noted, the ewe apparently did not discharge the afterbirth, for there was none found at that time anywhere around the birth site. The next day, however, a pile of gravel was noticed in the immediate vicinity. This was dug into two days later and the afterbirth found. Such concealment evidently is an instinctive precaution to preclude attracting predators by odor to the scene where the young would be endangered. The site was about one-fourth mile distant from the point where the group of fourteen sheep was seen.

On February 20, I returned to the scene with Mr. Eli Rawlings, a refuge cooperator, from Las Cruces, at 3:30 P.M. The ewe was seen climbing the mountain in flight as if very frightened. This permitted the taking of only one photograph of her at that time. The first photograph of the lamb was taken when twenty-eight hours and thirty-five minutes old. We remained with the lamb for thirty-five minutes. While photographing, it was handled only with sticks in order not to transmit human scent to it. As we left and climbed up the canyon on our return to Las Cruces, we saw two Golden Eagles in the immediate vicinity.

On February 22, I revisited the place where the lamb was born. As I topped a small five-foot cliff to arrive about forty feet from the site, I noticed the ewe, appearing very nervous, on the side of a hill above where the lamb was born. A golden eagle was feeding

on something about thirty feet away. The bird flew away immediately. When I went to where the eagle had been feeding, I found it had been devouring the lamb. The mangled body of the lamb, although in the shade, was still warm from body heat. I then walked to the exact site of the birth and looked for predator sign, but not one track of any kind of mammalian predator was to be found. Claw marks of the eagle were seen in the gravel where the lamb was born. There, also, were the hoof prints of the ewe, deeply imbedded, to indicate an effort to protect her young from the eagle's onslaught. What was left of the lamb's carcass was collected and stored in the saddle shed at Rope Springs for possible future study. Photographs were made of the lamb before and after death.—CECIL A. KENNEDY, *U. S. Fish and Wildlife Service, San Andres National Wildlife Refuge, Las Cruces, New Mexico.* *Received June 28, 1947.*

CATS KILL DEER

It apparently is not common knowledge that bobcats (*Lynx rufus*) kill deer. Years ago, when small game was plentiful in Pennsylvania, and deer were scarce, bobcats did live largely on small game. During the several years just past, I have followed the nightly hunting trails of cats many miles, studying their motives, and have seen little indication of their interest in small game. During that time I have come upon many dead deer, killed by cats, where the evidence on fresh snow was unmistakable. This was in Pennsylvania State Lands, in areas not accessible by roads after the early snows and not visited by others than my party, including local foresters and wardens, during the winter months. These conditions preclude the possibility of the deer having been wounded or killed by men. In cases where there was the possibility of their having been killed or wounded during the deer season, such cases were discounted.

In recent years, small game (rabbits and grouse) has become very scarce while deer have increased to the maximum. Although the cats are by no means numerous, we have found as many as five deer in two weeks in a certain locality that were unquestionably killed by cats. Careful examination showed that these deer were unwounded and in good condition when killed. Most of these were fawns although occasionally a doe is killed. We have found several instances where a cat attacked a large deer which it could not overcome. A few cases have been reported, although such have not come under my personal observation, where cats have killed full grown bucks. In these cases evidence of considerable struggle was reported.

Ordinarily the cat circles the bedded deer, creeps to within about ten feet, and pounces. It seizes the deer by the head with its forepaws and holds the head down. Fawns and small deer seized thus are seldom able to get to their feet and are killed in their beds, leaving little evidence of struggle. The cat's killing hold is at the throat close behind the deer's jawbones. The skin is not broken except for the piercing by the four canine teeth. I have laid the throat skin back on deer and found the windpipe severed in some cases. Apparently this is done by grating the canine teeth thus cutting or pulling the windpipe apart. Frequently the cat then drags the deer a few feet, or a few yards. He usually begins feeding from the rear middle of the uppermost hind quarter, eating a portion about the size of the cat's head.

In the case of a kill found (in January 1947) before the carcass had cooled, the cat had eaten the entire hind quarter, had detached the bone from the hip joint, had eaten the loin, up to the ribs, and the side and belly meat, including hide and hair, and exposed the intestines. This was a fawn and the cat was an unusually large one.

On February 5, 1947, we studied the trail of a large cat which had followed three deer about a mile to where they had bedded down. The cat approached from several different angles (creeping). Finally, when about sixteen feet distant, the bedded deer bounded. It was in its second bound when struck by the cat. The deer was evidently too large (judging by its tracks and the size of its bed) and the cat could not make good his throat hold. The deer carried the cat forty to fifty feet into heavy brush where it was shaken off or more likely knocked off by saplings. There were slabs of deer hair the size of a man's hand, such

as might be slashed off by the stroke of a razor. The cat did not chase the deer after being shaken off. Within another mile, this same cat's trail met the tracks of several deer traveling (walking) at right angles to his course. He made four or five bounds after the deer, but failed to catch it.

In this locality (Slate Run, in Tioga and Potter Counties, Pennsylvania) the cats live almost exclusively on deer. Evidently the big cats do most of the killing, but they seldom return to the kill. In the case of two freshly killed deer (we were convinced both kills were made by the same large cat) the killer did not return, in one case during a two weeks period, in the other a four weeks period. On two or three occasions he passed within a few rods of them; no other cats found either of these two kills. Traps were set at the kills and visited daily. This, and the fact that all cats killed in this locality are very fat, indicates their ability to kill a deer when and where required.

Indications are that they feed irregularly, gorging on occasion and at times not feeding for several days. They commonly remain in their resting places during a storm and appear to be reluctant to travel in deep, soft snow. On a recent hunt, following an eight inch snowfall, no tracks were found during the storm nor during the following week.

A female, weight sixteen pounds, had one-eighth to one-half inch of fat under the hide on the belly; the abdominal cavity was completely filled with firm white fat. The stomach and intestine were empty except for a small amount of thick, dark, semi-fluid material in the intestine and a small wad of fine fur, probably rabbit or rat (rabbits are rare in that locality). This is the only specimen examined in that locality, during several years past, that showed stomach content other than deer meat.

In a male, weight sixteen and one-half pounds, the stomach was distended with deer meat and hair; no other material was present. The intestine contained wads of deer hair. A layer of fat one-half inch thick covered the belly. The stomach, intestines, and kidneys were completely encased in firm white fat. Porcupine quills were embedded in the fore legs and back of this specimen.—J. R. Matson, *Perry, N. Y. Received Mar. 28, 1947.*

WOODCHUCKS OBSERVED WHILE FIGHTING

On the morning of April 22, 1946, about three miles south of Delmar, Albany County, N. Y., it was my good fortune to witness a fight between two woodchucks (*Marmota monax*). About 9:30 A.M., while posting a letter in the roadside mailbox outside the Wildlife Research Laboratory, I heard considerable squealing and scuffling on a hillside about eighty yards distant across a gully. Through the open stand of hardwoods, two woodchucks could be seen fighting among the dry leaves at the base of a large red oak, beneath whichI knew a woodchuck den to be located. The smaller of the two animals suddenly turned and ran diagonally downhill toward me, into the intervening gully, with the larger one in close pursuit. After running perhaps thirty feet, they passed behind a screen of bushes and, from the noise which ensued, it seemed evident that the battle had been resumed. In a few seconds the sounds ceased and the larger woodchuck reappeared, retraced its route in a leisurely manner, and disappeared in the den.

I hastened down the slope with the intention of ascending the other hillside in search of the smaller woodchuck. Upon reaching the small brook, which flows through the ravine, I came upon the animal resting with its hind quarters on the far bank, fore quarters in the water, and chin just afloat. It watched me closely and bit savagely at a stick held near its nose; however, it made no effort to escape. I stepped across the stream, at this point about four feet wide and six inches deep, and approached the 'chuck. It immediately withdrew from the water and started to crawl feebly away, whereupon I dispatched it with a sharp blow of a stick.

Upon skinning the animal, a small male, no wound of any sort was found but the one inflicted by me. The weight was 4660 grams; total length 550 mm.; hind foot 85 mm.

It seems likely that this was one of the young of the preceding year being driven from the home den to shift for himself.—Charles P. Brown, *Wildlife Research Laboratory, Delmar, New York. Received July 1, 1947.*

SPEED AND GAIT OF AN OTTER

The otter (*Lutra canadensis*) is seldom found in a location where its maximum speed over ice and snow and its gait can be closely observed. But such an opportunity was afforded the authors on March 28, 1947, while they were traveling on a snowmobile (a toboggan powered by a motorcycle engine and propelled by a single caterpillar tread) across an impounded stretch of water approximately one-half mile wide and four and one-half miles long. The area is known as Cedar River Flow and is located in Lake Pleasant township, Hamilton County, New York.

Patches of wind-packed snow covered about half of the ice surface of the flow. The snow was solid enough to allow a man to walk without snowshoes. The otter, an adult of average size, was first observed at a distance of about one-half mile. It took us about five minutes to catch up with the otter and when we pulled in behind it, at a distance of about 200 feet, an increase in its speed was noticed. We soon out-distanced the animal and it turned back down the flow. During the next ten minutes, we chased it north, then south, then north, and finally south again. It ducked under a stump or tree trunk, that protruded through the ice, to evade us. We had to circle these objects and while doing so the otter reversed its course. Also, each time it turned, some progress was made toward shore so that on the fourth leg it entered the dense alders bordering the flow and we could follow no further. During all this time the otter was traveling about fifteen to eighteen miles an hour, judging by the fact that we were traveling just under maximum throttle and our maximum speed was about twenty to twenty-two miles an hour. On each leg of the chase we were traveling most of the distance abreast of the otter and no more that three or four feet from it. The chase was sufficiently fast and long that the otter's mouth was open and its tongue could be seen. But in spite of the chase and the distance it traveled before the chase (back tracking showed it had come from the foot of the flow about four miles distant) there was no slackening of its pace as long as we observed it.

The otter's gait during the course of the chase was very even. It would jump forward just three times, no more no less, and then glide. The glide would extend about twenty to twenty-five feet over the ice, but over the wind-packed snow the distance was somewhat shorter. Its jumping and gliding were so timed that no appreciable loss of speed was noticed.

The motion of the feet and body was interesting. Before each jump the body was bent up like a hairpin (resembling a doubled up inch worm) and the tail was raised slightly above horizontal. In springing forward from this position, it straightened its body and tail, thus raising its front feet off the snow, and in the same motion shoved forward with its hind feet. The motion of the tail, body, and hind feet were coordinated for propulsion. Its body barely cleared the snow or ice in the jump. During the glide, the front legs and feet were held parallel to the sides (not under the body) and the hind feet and legs were straight back along the sides of the tail. It was not possible to determine how the hind legs changed from this position to the doubled up position ready for the first jump after the glide. But from our observations it was deduced that at the end of a glide the front feet dug into the snow and the body doubled up so that the hind feet naturally came into position for the next jump. This was done so easily and quickly that no loss of momentum was noticed.—C. W. Severinghaus and John E. Tanck, *Wildlife Research Laboratory, Delmar, N. Y. Received July 7, 1947.*

ANTLER-BEARING BY A FEMALE SIKA DEER

Female elk (*Cervus*) and deer (*Odocoileus*) are occasionally found with rudimentary antlers. To those already reported, we should like to add a record of a doe sika deer (*Cervus nippon*) in the collection of the San Diego Zoological Gardens. She boasts a set of simple antlers, one of which measures approximately four inches, the other approximately six inches. Last year she grew only a pair of inconspicuous knobs. The age of the antler-bearing doe is not known.—Jordan S. Roux and Ken Stott, Jr., *Zoological Society of San Diego, San Diego, California. Received June 17, 1947.*

PORCUPINES GNAW BOTTLES

When the big flood went through Pittsburgh, Wheeling, and other points on the Ohio River (March 1936), I was marooned for several days in the mountains of northern Pennsylvania by snow and frozen rain. I had gone back into the hills a few miles from Clarendon, Pennsylvania, where the Wildcat and the Tionesta join, to watch and photograph some of my friends who were trapping beaver not far from the cottage of the State game warden, Mr. John Hopkins.

Cut off completely from Clarendon and the world by the snows, and short of food, we lived largely on beaver, and listened to the warden's radio reporting the floods downstream. Mr. Hopkins, finding that I was a glass technologist, among other things, asked if I had seen, in the woods, bottles and glassware chewed by porcupines (*Erethizon dorsatum*). I had not, and he found several pieces for me. The prize exhibit was a catsup bottle chewed

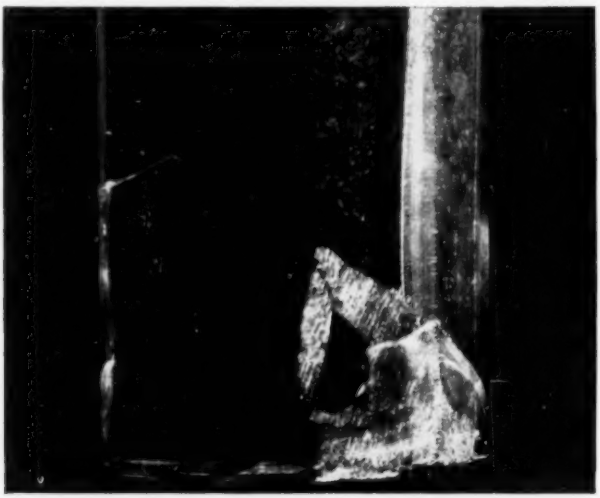

PLATE I

Bottle gnawed by porcupine

completely through. He assures me this is the work of porcupines, or of beavers, and he believes it must be porcupines. This bottle (Pl. I) is also chewed at the top or "finish."

A number of other examples show more clearly how the animal works. He gets one set of teeth (presumably the upper incisors) against an *edge* and gnaws towards this with the other (presumably the lower) set. Thus he gradually wears a concavity into the flat or flattened *face* of the glass. He generally *chips* the edge, leaving it very irregular and ragged. Most often the teeth do not meet at the end of the stroke, so there is a narrow ungnawed zone just short of the edge. Most of the other specimens I have are less spectacular than the one figured, but even more obviously the work of a rodent.

It is well known, of course, that porcupines will eat almost anything from houses to aluminum pans and outboard motors. Mr. Hopkins tells me they eat up the fallen deer antlers, and will even come on to his porch after them. But glass is a pretty hard material and must be tough on the creatures' teeth. The reason for so much ambition is not clear. However, glass contains as a rule 14 to 18 per cent of soda (Na_2O), and this leaches slightly in the weather. Perhaps the animal likes alkali; he is said to be very fond of salt of more

kinds than one. The gnawed bottles are not all catsup bottles or we might suppose the salt of the contents to be the attraction. In general, bottles are gnawed only at places where an edge gives a purchase for the stationary teeth, in all my examples.—F. W. PRESTON, *Preston Laboratories, Butler, Pennsylvania. Received Jan. 20, 1947.*

SARCOPTIC MANGE IN THE RED FOX IN OHIO

From July to November of 1946 severe cases of mange were observed in ten dead or dying red foxes (*Vulpes fulva*) in Tuscarawas County, Ohio. These cases were reported by Charles V. Riley who is responsible for the field observations and collections. Three of the foxes were sent to the Ohio Wildlife Research Unit where the parasitological examinations were made by the senior author.

All three foxes were heavily parasitized with the mange mite *Sarcoptes scabei*. On the specimens examined, the mange had apparently started on the body just back of the shoulders from where it had spread to the neck and head, with the ears and forehead becoming involved last. However, in the case of the animal pictured in Plate I, the body had apparently become seriously involved, whereas, the head region was only slightly affected.

PLATE I

Red fox—severe infection with sarcoptic mange

Many small lesions were found on the sides and belly. The areas surrounding the lesions were highly inflamed and eroded. Undoubtedly the constant irritation due to the host's scratching and biting was responsible for this condition.

This specimen was later submitted to the Department of Veterinary Medicine, Ohio State University, for pathological examination and a diagnosis of gastroenteritis was made by Dr. C. R. Cole.

The helminth parasites of this fox consisted of one hundred ninety-three roundworms, identified as *Physaloptera rara*, taken from the stomach, and twenty-four specimens of the roundworm, *Toxocara canis*, recovered from the small intestine. There is little doubt but that the enteritis was caused by the attachment of these worms as there was also some ulceration of the mucosa.

The general appearance of all the mangy foxes indicated a condition of malnutrition. Several foxes seen in the field were so listless that they could be easily picked up by hand. In two instances, foxes were killed by farm dogs. It is not believed that this enervated condition was a direct effect of parasitism. Instead it seems probable that the mange mites had affected the feeding of these animals and, therefore, had contributed to the malnutrition of the foxes.

According to the pre-hunting season game survey conducted by the Ohio Division of Conservation, it was disclosed that the red fox population was exceedingly high in Tuscarawas and adjoining counties. Therefore, it seems likely that the cases of parasitism might be the result of overcrowding of the hosts.—JOHN R. OLIVE AND CHARLES V. RILEY, *Ohio Cooperative Wildlife Research Unit, Ohio State University, Columbus 10, Ohio. Received July 5, 1947.*

SYNAPTOMYS ON THE HIGHLANDS, NORTH CAROLINA, PLATEAU

During June, 1947, characteristic signs (cuttings and green droppings) of *Synaptomys* were found in two different small sedge-sphagnum bogs on the Highlands, North Carolina, plateau, but after a week of continuous trapping only a single specimen of the bog lemming, *Synaptomys cooperi*, was obtained (University of Georgia, no. 197). This record is the southernmost reported occurrence of this species. The mountain race, *Synaptomys cooperi stonei*, has apparently been recorded from but two other localities in western North Carolina, Mitchell County (Merriam and Rhoads, 1892–95) and Madison County (Marshall, 1909) according to C. S. Brimley's "Mammals of North Carolina" (Carolina Tips, 8: 18, 1945). Highlands, in Macon County, is less than ten miles from the Georgia line. The specimen was taken three miles east of the town at an altitude of 4000 ft. It was trapped in a dry portion of the bog near a spot where a specimen of *Microtus pennsylvanicus* was taken. Unfortunately, when removed from the trap the animal had been partly destroyed, but I was able to save most of the skin. The skull was in perfect condition.—EUGENE P. ODUM, *University of Georgia, Athens. Received July 14, 1947.*

MICROTUS FROM THE PIEDMONT OF GEORGIA

During the fall and winter of 1946–47 when considerable trapping for small mammals was carried out in the vicinity of Athens, Clarke County, Georgia, seven specimens of *Microtus pennsylvanicus*, all of which are preserved in the University of Georgia Collection, were secured. This is apparently the first record for the genus *Microtus* in Georgia. No previously published record has come to my attention. Drs. H. H. T. Jackson and Remington Kellogg of Washington and E. V. Komarek of Thomasville, Georgia, write that they know of no previous specimens of *Microtus* having been taken in the state. Two skins examined by Dr. Jackson have been tentatively referred to *M. p. pennsylvanicus* until a larger series can be studied.

The first three specimens were obtained in a wet meadow located in the Sandy Creek Bottoms, two miles north of Athens, November 23, 1946. Another animal was obtained in the same area on January 28, 1947. Several rice rats (*Oryzomys palustris*) were also taken in the meadow and adjacent marsh. It would seem logical to assume that as a northern animal reaches the southern extremity of its range it would most likely occur in a cool, moist habitat such as a wet meadow. Hence, it was something of a surprise to obtain three additional specimens of *Microtus* in a large, dry, upland broomsedge field near the University of Georgia campus and some distance from water. Two of these were taken in a quarter-acre quadrat along with fourteen *Sigmodon hispidus* and two *Reithrodontomys humulis*.

It is probable that *Microtus* merely has been overlooked in Georgia, since little mammal work has been done, particularly in the northern part of the State. On the other hand, it is possible that *Microtus* is extending its range southward as has been the case with robins, song sparrows, and other birds of early seral habitat. *Microtus* has certainly benefited by white man's wholesale creation of grasslands in the originally forested eastern United States and its reproductive potential makes it capable of rapid spread.

I wish to thank Messrs. Jackson and Komarek, who verified the identification, and students Dave Johnston, Willard Gaulding, Raymond Jordan, Sidney Hutcherson, and Israel Fitterman, who aided in trap setting and specimen preparation.—EUGENE P. ODUM, *University of Georgia, Athens, Georgia. Received July 14, 1947.*

EXTENSION OF RANGE OF *TAXIDEA TAXUS SONORIENSIS*

In February, 1947, Arthur F. Halloran, Yuma, Arizona, collected three badgers in the Castle Dome Mountains, Kofa Game Range, Yuma County, Arizona (Fig. 1). No badger specimens from this area were previously represented in the Biological Surveys collection.

The senior author identified these three adult specimens (two males and one female) as *Taxidea taxus sonoriensis* Goldman, previously recorded only from Camoa (type locality) and Costa Rica Ranch (about forty miles southwest of Hermosillo), Sonora, Mexico. These

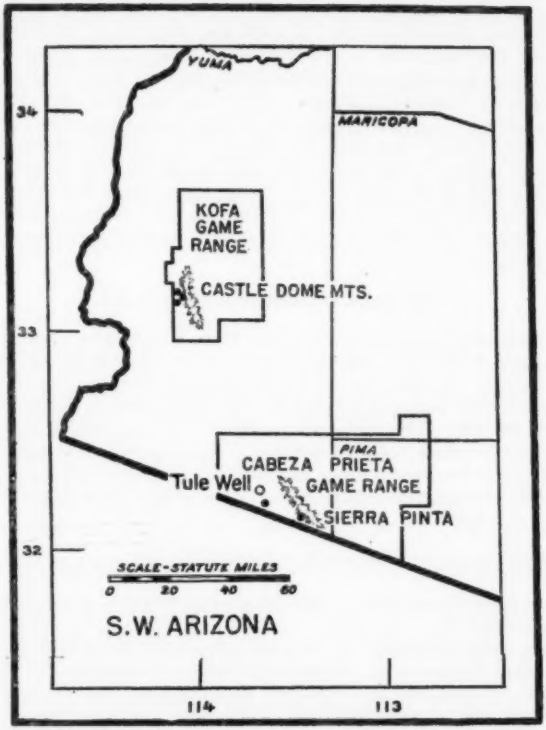

FIG. 1.—Map showing Arizona records of *Taxidea taxus sonoriensis*.

additional specimens from the Kofa Game Range (114° 10′ W. and 33° 10′ N.) extend the range of *sonoriensis* 325 miles northwest from previously reported localities, and into the United States.

The junior author also collected a specimen four miles southeast of Tule Well, Yuma County, and another at the south end of the Sierra Pinta, two miles across the border of Sonora in Yuma County, Arizona. These two specimens from the Cabeza Prieta Game Range are also referable to *T. t. sonoriensis*.—VIOLA S. SCHANTZ AND ARTHUR F. HALLORAN, *U. S. Fish and Wildlife Service, Washington, D. C. and Yuma, Arizona. Received July 5, 1947.*

THE JUMPING MOUSE IN GEORGIA

A jumping mouse (*Zapus hudsonius americanus*) captured on September 22, 1944, near Athens, Georgia, has since proved to be the first record for the family Zapodidae in Georgia.

The specimen was procured alive from a newly-dug pit in a small area overgrown with tall grass. The skin and skull of this animal, a female, are now in the collections of the U. S. Fish and Wildlife Service, National Museum, Washington, D. C.

Because of the limited descriptions of the young, the following data may also be of interest. Upon first being captured, the animal was caged. On the evening of September 29, three tiny live young were found scattered about the cage. These were replaced in the grassy nest constructed by the parent. The next morning, the adult was dead. Upon dissection, six uterine scars were observed. Further search of the cage disclosed the additional scattered young, all dead. In view of the lack of parental care, it seems doubtful that the young were more than a day old when first discovered. At that time they were entirely naked. One measured: total length 34 mm., tail 10 mm., hind foot 5 mm. The eyes were merely pigmented areas beneath the skin (1.2 mm., diam.) and no external openings to the auditory canals were evident. The young mice were able, however, to utter high-pitched squeaks. The hind legs were no longer than the front ones. Though actively writhing, the three young found alive were capable of no effective locomotion.

The author is indebted to Miss Viola Schantz and Mr. H. H. T. Jackson, U. S. Fish and Wildlife Service, Washington, D. C., for identifying the specimen and to Dr. Eugene Odum, University of Georgia, Athens, Georgia, for pointing out the value of the record.—George A. Petrides, *Ohio Wildlife Research Unit, Ohio State University, Columbus 10, Ohio.* *Received Sept. 18, 1947.*

ANOTHER OKLAHOMA ARMADILLO

Recently, while examining some specimens from the Wichita Mountains Wildlife Refuge, Oklahoma, in the U. S. Biological Surveys Collection, I noticed a single specimen of *Dasypus novemcinctus texanus*. It was collected by Frank B. McMurry on May 31, 1939. Earlier Oklahoma records have been noted in the *Journal of Mammalogy* (Blair, vol. 17: 293–294; Taber, vol. 20: 489–493). The northernmost record (known to me) is that of a specimen collected by Louis Smith eight miles northwest of Freedom, Woods County, November 29, 1941 (Kalmbach, *The Armadillo*, Texas, Game, Fish and Oyster Commission and the U. S. Fish and Wildlife Service, 1943).—Marshall C. Gardner, *U. S. Fish and Wildlife Service, Washington, D. C.* *Received July 22, 1947.*

RECORDS OF *KOGIA BREVICEPS* FROM THE HAWAIIAN ISLANDS

Although the pigmy sperm whale, *Kogia breviceps* (Blainville), doubtless has a very wide distribution, most specimens have been recorded from areas of the western Atlantic and Pacific Oceans. Such information as is known regarding the species has accumulated largely from a study of specimens stranded on beaches here and there in widely separated localities. That the dispersal of *Kogia* may be correlated with the food habits of the mammal, since its normal range seems to coincide with the larger ocean currents, is the suggestion of Glover M. Allen (Field Museum of Nat. Hist., Zool. Ser., 27: 17–36, 1941) who presented a summary of all of the known records of this whale up to the time of his report.

According to Allen's account, of the twenty-six reported occurrences of this mammal in the Atlantic Ocean, six are from South African and European waters, while twenty instances of its appearance are from the North American coast, extending from Florida to Nova Scotia. In the Pacific Ocean, are numerous records of *Kogia* from New Zealand, Eastern Australia, East Indies, Indo-China, and Japan. A few specimens have also been taken in the northern Indian Ocean. Only twice has the pigmy sperm whale been reported from the eastern Pacific Ocean. One specimen was found near Mazatlan, Mexico, in 1868, and an imperfect cranium was picked up on the beach at Independencia Bay, Peru, in November, 1919.

A specimen of *Kogia breviceps* was taken, by spearing, in Kahului Harbor, Maui, by Wesley Wong of Kahului, early in 1942. No announcement of this capture was made until

very recently. The lower jaw of the specimen was preserved by Mr. Wong, and is said to be considerably larger than that of a specimen taken near Lahaina in 1947.

This capture of 1942 by Wesley Wong, therefore, represents the first record of the pigmy sperm whale having been taken in the Hawaiian area.

On April 5, 1947, a Philippino fisherman in the vicinity of Lahaina, Maui, Hawaiian Islands, was fishing for *ulua* with a hand line, the hook baited with a piece of *aku* meat. A sudden strike initiated a struggle which finally resulted in the fisherman, with badly burned hands, landing on the beach the largest "fish" he had ever taken. Mr. D. T. Fleming of Lahaina, recognizing the catch as a strange mammal, secured the lower jaw which later was identified by Dr. Remington Kellogg, Curator of Mammals, U. S. National Museum, as belonging to *Kogia breviceps*.

Mr. Fleming, who supplied information about the specimen, reports that it was 7 feet long and weighed approximately 300 pounds. He further states that it was dark bluish gray all over, although probably lighter on the underside. It had a thick, heavy tongue and the eye was very small, set far back and low down on the head. Although no teeth were observed in the upper jaw, they might easily have been overlooked, as the upper teeth of this species usually number not more than two on each side and are small, spicular in character.

The data in Table 1 apply to the mandible of the Maui specimen, which is somewhat imperfect behind.

TABLE 1

Length of right side (imperfect behind)	200 mm.
Length of alveolar portion	90 mm.
Length of symphysis	34 mm.
Breadth of mandible at symphysis	20 mm.
Depth of mandible, anterior extremity of symphysis	10 mm.
Depth of mandible, level of second tooth	20 mm.
Depth of mandible, level of fourth tooth	15 mm.
Width between posterior borders of rami (imperfect)	155 mm.
Number of teeth, right side	11
Number of teeth, left side	13
Length of one of the longer teeth	20 mm.

Teeth cylindrical, very sharp, slanting backward and curved inward.

The Hawaiian specimen (sex undetermined) was apparently not full grown. Eleven feet is the maximum length reported for a male of this species, and ten and one-half feet for a female. This remarkable capture of *Kogia breviceps* seems to establish the second record of the species in the central Pacific area, and probably represents the first time the pigmy sperm whale has been taken by means of a hand line. The lower jaw of the Maui specimen is in the Bishop Museum, Honolulu.—C. H. EDMONDSON, *Bishop Museum. Received July 15, 1947.*

WATER SHREW IN WESTCHESTER COUNTY, NEW YORK

An adult female water shrew, *Sorex palustris albibarbis* (Cope), was found in the stomach of a sixteen-inch, one and one-half pound brown trout, taken by Mr. Asahel Waite of Katonah, New York, from Beaver Dam Brook, April 19, 1947. The identification was confirmed by Messrs. G. G. Goodwin and T. D. Carter of the American Museum of Natural History.

This appears to be the first record for Westchester County. Evidently, the fish had just swallowed the shrew because there was no evidence of digestion. The shrew had been badly bitten on the back and tail. It probably had been captured by the trout in the immediate vicinity of the deep pool. Records show that no trout had been stocked in the stream for several weeks previous. I relaxed the specimen and made it into a study skin. The measurements are: total length, 141 mm.; tail, 62 mm.; hind foot, 18 mm.—STANLEY OLIVER GRIERSON, *44 Sunrise Ave., Katonah, New York. Received June 2, 1947.*

REVIEW

Tate, G. H. H. MAMMALS OF EASTERN ASIA. New York: The Macmillan Co. Pp. xiv + 366, 79 figs.

This volume is the eighth and last of the publications in The Pacific World Series, each of which was published under the auspices of the American Committee for International Wild Life Protection. The authors and subjects of earlier volumes in the series are as follows: THE PACIFIC WORLD, edited by Fairfield Osborn; MAMMALS OF THE PACIFIC WORLD, by T. D. Carter, J. E. Hill, and G. H. H. Tate; INSECTS, by C. H. Curran; NATIVE PEOPLES, by F. M. Keesing; REPTILES, by Arthur Loveridge; PLANT LIFE, by E. D. Merrill; and FISHES AND SHELLS, by J. T. Nichols and Paul Bartsch.

As conceived in the series, the Pacific World includes the vast area of the Pacific Ocean extending from the Aleutian Islands at north, southward through Japan, the Philippines and East Indies, to Australia and New Zealand. In short, it is the region many Americans visited recently as guests of the United States Military Authorities. Before the recent campaigns against Japan, most of the islands and archipelagoes in the Pacific were to the layman merely dots on a map. To him, those dots represented lands in another world that, unfortunately, was of slight interest and importance. But when he suddenly found himself on one of those islands, or when he received word of a son's or daughter's activities at one of those distant points, the island areas assumed importance and meaning. It was to supply information about those areas to military personnel and to interested friends and relatives back home that the Pacific World Series was inaugurated. At the same time it was hoped that the newly enlightened public would become a conservation-minded public which would support conservation of the native faunas and floras insofar as militarily expedient. With those purposes in view, the authors of the volumes have provided in simple terms, salient facts on the origin, distribution, and life history of the biota of the region. None of the accounts is intended to be comprehensive and exhaustive of the available subject matter. And, for the lay group for which the accounts are intended, they should be cursory summaries.

The present volume, although originally announced as one of the Pacific World Series, pertains to the mammal life of the mainland of eastern Asia, from Mongolia south to Burma and Malaysia. The method of treatment of the mammal kinds is similar in the present and the earlier volume of which Mr. Tate is also an author. Most of the book—325 pages—is devoted to descriptions of the mammals of eastern Asia. A species account typically contains a brief description of the kind, a few words on its distribution in the region, and mention of geographic races which have been recognized. A few life history notes are included in some accounts. Seventy-six original drawings in black and white illustrate some of the kinds. A section entitled "The Home Territories of Eastern Asiatic Mammals" is of interest. Therein are described and figured political, physiographic, and biogeographic areas—life zones and faunal areas. Most of the information in the book is available in more detail in other publications, but those publications are known to the specialist, not to the layman. The author has successfully condensed a mass of information to a level suitable for a popular handbook.

One may contend that most of the books in the Pacific World Series were published too late to meet the peak of interest in the region. Only one of the series appeared before 1945. Now, when most of the military forces are withdrawn from the far Pacific areas, has the demand and appeal for the information disappeared? I think not. A former military occupant of an island in the Pacific may well derive more pleasure in reading of the area from a great distance and in considering the Pacific World in retrospect rather than in circumspect.—EMMET T. HOOPER.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma Charters)
[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENT AND NEWS

MILLER'S CHECK LIST REVISED

Dr. Waldo L. Schmitt, Head Curator, Department of Zoology, U. S. National Museum, informs us that the manuscript for a revised CHECK LIST OF NORTH AMERICAN MAMMALS, by Gerrit S. Miller, Jr., will go to the printer this fiscal year. Mammalogists are grateful to Mr. Miller for his continued efforts, and to the authorities of the U. S. National Museum for assuming the responsibility of printing the results of Mr. Miller's work. We shall be looking forward to the time of its release.

EDITORIAL POLICY

The new Editorial Committee wishes to state some of its policies for handling manuscripts submitted for publication in the Journal. Starting with this issue, the date of receipt of the manuscript, in acceptable form, will be printed at the end of each article. It will not be possible, nor is it desirable, to adhere strictly to chronological order. Short articles, although submitted later, will often appear before long ones. Further, it will be necessary, at times, to place some articles ahead of others to maintain a balanced Journal. Manuscripts prepared in proper form will sometimes have priority over those which require considerable work to put them in shape for printing. If contributors will scan recent numbers of the Journal for form, and prepare manuscripts accordingly, it will save the Editorial Committee much time. Here are a few suggestions to our contributors: Tables, legends to figures and plates, and Literature Cited should be typed on separate sheets, *not in the running text*. Always double space, leave good margins, and avoid footnotes.

Your Committee will welcome your suggestions for improving the Journal. It will also appreciate your cooperation in preparing good clean manuscripts before submitting them for publication.

NOTICE OF ANNUAL MEETING

The twenty-eighth annual meeting of the American Society of Mammalogists will be held at the Royal Ontario Museum of Zoology, Toronto, Ontario, April 11–14, 1948. The regular meetings will be held in the theater of the Museum on Monday, Tuesday, and Wednesday. The directors' meeting will be at the Royal York Hotel, Sunday evening, April 11.

Headquarters for the Society will be at the Royal York Hotel. Fifty double rooms have been reserved for the meeting. The rates are $4.25 per person with two to a room. Only by arranging to have two persons to a room will it be possible for the organization to be accommodated in crowded Toronto. In rare instances it may be possible to have a single person in a room and then the minimum rate will be $5.00. All requests for reservations should be sent directly to the chairman of the local committee, who will make arrangements for the sharing of rooms by members. Persons desiring to share rooms with specific individuals should so indicate. The other hotels at which members may find space, but to which they must write directly for reservations, are: Walker House Hotel and King Edward

Hotel. Kindly inform the chairman of the local committee at your earliest convenience whether you intend to attend the meetings. Only thus can he make proper accommodations and arrangements for all. The chairman is Mr. Randolph L. Peterson, Division of Mammals, Royal Ontario Museum of Zoology, Toronto, Ontario.

The local Committee on Arrangements for the annual meeting is as follows:

Dymond, J. R., Honorary Chairman
Anderson, R. M.
Banfield, Frank A.
Clarke, C. H. D.
Coventry, A. F.
Cowan, Ian McT.
Cross, E. C.
Campbell, J. A.
Downing, S. C.
Edwards, R. Y.
Fowle, C. D.
Laurie, A. H.
Russell, L. S.
Snyder, L. L.
Stinson, R. H.
Peterson, R. L., Chairman

This is the first meeting our Society will have held in Canada. An interesting and lively program is in store. The success of the program depends upon the participation of the members. Plan to attend, meet our colleagues to the north, and present a paper.

CALL FOR PAPERS

If you intend to present a paper at the twenty-eighth annual meeting of the American Society of Mammalogists, Toronto, Canada, April 11–14, 1948, please send to the Corresponding Secretary, Dr. Donald F. Hoffmeister, Department of Zoology, Museum of Natural History, University of Illinois, Urbana, Illinois, before April 1, 1948, the following information: Title, time required, type of projection apparatus, if any, and, if you desire, a brief abstract of the paper.

Papers may be submitted on any phase of mammalogy. They should not exceed twenty minutes in length. Good motion pictures are always welcome. **Submit your title for a paper now.**

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

At the Twenty-seventh Annual Meeting of the American Society of Mammalogists, it was voted that the Society accept the recommendation of the Board of Directors to affiliate with the American Institute of Biological Sciences. Affiliation with the American Institute of Biological Sciences will increase the annual dues of the members of the American Society of Mammalogists. As this will require an amendment to the by-laws of the constitution, the matter is being brought before the entire membership for their consideration and action.

The American Institute of Biological Sciences is organized to serve those common interests of the biological sciences that can best be dealt with by cooperative action of the constituent societies. As indicated in its constitution, the purposes of the Institute are the advancement of the biological sciences and their application to human welfare. To serve these purposes, the Institute will, among other things, (1) assist societies and other organizations in matters of common concern that can be dealt with most effectively by united action; (2) cooperate with local, national, and international organizations concerned with the biological sciences; (3) promote unity and effectiveness of effort among those interested in the biological sciences either as teachers, students, or investigators; and (4) improve the relations of the biological sciences to other sciences, to the arts and industries, and to the public welfare.

This Institute should serve to guard the interests of biologists in the event of national emergency and to ensure that the services of biologists are wisely employed. Furthermore, it should represent biologists in public and professional relations and in the proposed governmental support of research.

The American Institute of Biological Sciences is made up of affiliated societies, each member of which is also a member of the Institute. Each affiliated society is entitled to elect one director to the Institute for a term of four years, and the directors constitute the

Governing Board. Officers of the Institute are a Chairman, a Vice-chairman, and an Executive Secretary.

A united biological group which can achieve results similar to those of the American Chemical Society, the Institute of Physics, or the American Medical Association, must have adequate funds. Past attempts to form a central biological organization have failed for lack of funds. To prevent a similar failure it has been decided that each affiliated society shall pay annual dues of $1.00 for each of its regular members.

The American Society of Mammalogists must therefore increase the annual dues of each member by $1.00 if it is to affiliate with the American Institute of Biological Sciences, and this will require an amendment to the by-laws. Such an amendment is proposed below. The opinion of the majority of members voting on this amendment will decide the action of the Board of Directors at the Twenty-eighth Annual Meeting of the American Society of Mammalogists to be held in Toronto, April 12–14, 1948.

Under separate cover, each member in America will receive a ballot on which he can vote. The marked ballots are to be returned to the Corresponding Secretary, Dr. Donald F. Hoffmeister, Museum of Natural History and Department of Zoology, University of Illinois, Urbana, Illinois.

PROPOSED AMENDMENT TO THE BY-LAWS

The amendment, recommended by the Board of Directors, is herewith offered for consideration of members of the Society. It is proposed that Section 1 of Article VIII which now reads:

Sec. 1. Annual dues for members shall be three dollars, payable in advance.

be amended to read:

Sec. 1. Annual dues for members shall be four dollars, payable in advance.

MAILING DATES FOR VOLUME 28

Vol. 28, No. 1, February 17, 1947
Vol. 28, No. 2, June 1, 1947
Vol. 28, No. 3, August 20, 1947
Vol. 28, No. 4, December 1, 1947

OBITUARY NOTICES

REGINALD INNES POCOCK, F.R.S.

R. I. Pocock, the senior of European mammalogists, died in London on August 9, 1947, suddenly and in the middle of active work, at the age of eighty-four. He was curator of spiders and myriopods at the British Museum from 1885 to 1904, superintendent of the London zoo from 1904 to 1923, and returned to the museum in 1923 where he worked until his end in the collection of mammals. His studies dealt both with the major classification of mammals, where he emphasized the importance of external characters frequently overlooked, and with the finer taxonomy of species and subspecies. An indefatigable worker, he was the author of part of Sclater and Thomas' Book of Antelopes, the primates and carnivora in the Fauna of British India, and an immense number of papers, full of valuable information, on many groups. He built up a superb collection of carnivora in the museum, but did not live to finish his Catalogue of the Felidae nor the volume on Indian ungulates. He was a very charming man, retiring in his habits, bluntspoken—a good and trusted friend to those who knew him well.—ERNST SCHWARZ

JOHN ERIC HILL, 1907–1947

John Eric Hill, Associate Curator of Mammals at the American Museum of Natural History and a member of the Board of Directors of the American Society of Mammalogists, died on July 8, 1947, at New York, N. Y. He was born on July 27, 1907, at Devon, New Brunswick. Upon entering the University of Kansas, his boyhood ambitions were realized when he met C. D. Bunker, Curator of Birds and Mammals, and was given a job as museum assistant to care for the collection of recent mammals. This collection was under his care until the summer of 1931. He accompanied Mr. Bunker on three collecting trips. In the summer of 1929, they collected in the regions of central and south central New Mexico; the summer of 1930 was spent in the Mogollon Mountains of New Mexico; and, during the summer of 1931, he was a member of an expedition into south central Arizona. He received his A. B. degree from the University of Kansas in the spring of 1931 and entered the University of California that fall. Here, he received his Ph. D. degree in 1934. During the period of graduate study he held a position as teaching assistant in Zoology. The following year he was appointed to the position of Research Associate in the Museum of Vertebrate Zoology at the University of California.

In 1935, Dr. Hill became Assistant Curator of Mammals at the American Museum of Natural History. In 1937, he and Mrs. Hill were sent to Europe to study specimens of African mammals in the museums of Holland, France, Belgium, Germany, and England under a Carnegie grant. While with the American Museum he made the following expeditions. He and Mrs. Hill collected mammals in New Brunswick, August 9 to September 9, 1936; in the summer of 1938 he collected in northeastern New Mexico, near Cimarron, Colfax County. The summer of 1940, accompanied by Peter E. Crowe and Mrs. H. L. Hill, he collected in the Meade Basin of southwestern Kansas, the San Luis Valley of Colorado, and Oklahoma. January 16 to March 2, 1943, were spent by him and Mrs. Hill studying and collecting specimens of *Neofiber* in Florida. They returned in November of that year and continued the study until February of 1944. They brought live specimens of *Neofiber* to the Laboratory of the American Museum for further observations and study.

Though his publications have not been numerous they give to the student of mammalogy sound basic findings in mammalian anatomy, natural history, and taxonomy. He was never too busy to help his fellowmen, and lived for the pleasure he derived from helping them. His unselfish, wise, and unexcelled counsel was often given at the expense of his own work and career. In the untimely death of John Eric Hill, America lost not only one of its greatest minds in the field of mammalogy, but a kind, understanding individual with malice toward none.—C. W. HIBBARD

WILFRED H. OSGOOD

Dr. Wilfred H. Osgood died June 20, 1947, after a brief illness. A full account of Dr. Osgood's life and works is planned for the May issue of this Journal.